Lloyd's Register

Rules and Regulations for the Classification of Naval Ships, January 2013

Notice No. 3

Effective Date of Latest Amendments:

See page 1

Issue date: November 2013

RULES AND REGULATIONS FOR THE CLASSIFICATION OF NAVAL SHIPS, *January 2013*

Notice No. 3

This Notice contains amendments within the following Sections of the *Rules and Regulations for the Classification of Naval Ships, January 2013.* The amendments are effective on the dates shown:

Volume	*Part*	*Chapter*	*Section*	*Effective date*
1	1	2	3	January 2014
1	1	3	10, 15	January 2014
1	4	1	6	January 2014
2	1	1	4	January 2014
2	1	2	3, 17	January 2014
2	1	5	1	January 2014
2	2	1	1, 2, 15	January 2014
2	2	2	2	January 2014
2	2	3	1	January 2014
2	3	1	5	January 2014
2	3	2	2	January 2014
2	4	2	2, 3, 7	January 2014
2	4	3	1, 4	January 2014
2	4	4	2, 3, 6, 8, 9	January 2014
2	6	1	1, 2, 3, 4, 7, 9	January 2014
2	7	1	1, 4, 5, 11	January 2014
2	7	2	1, 11	January 2014
2	7	3	5, 11	January 2014
2	7	5	1, 5, 6	January 2014
2	8	1	15	January 2014
2	9	1	1, 2, 6	January 2014
2	10	1	1, 5, 7, 9, 10, 11, 13 14, 16, 17, 18	January 2014
2	12	1	Whole Chapter	January 2014
3	1	2	3	January 2014
3	1	3	1, 2, 5, 6	January 2014
3	1	5	6, 7	January 2014
3	3	1	4	January 2014

It will be noted that the amendments also include corrigenda, which are effective from the date of this Notice.

The *Rules and Regulations for the Classification of Naval Ships, January 2013* are to be read in conjunction with this Notice No. 3. The status of the Rules is now:

Rules for Naval Ships	Effective date:	January 2013
Notice No. 1	Effective date:	1 July 2013
Notice No. 2	Effective date:	1 January 2014
Notice No. 3	Effective date:	1 January 2014

Volume 1, Part 1, Chapter 2
Classification Regulations

Effective date 1 January 2014

■ *Section 3*
Character of Classification and Class notations

3.11 Tailoring – Departures from the Rules and Rule additions

3.11.4 A Technical justification is to be provided for each deviation from the Rule requirements. In some cases, a full justification~~, hazard analysis (HAZID)~~ and ~~risk assessment~~ Risk Assessment may be required. *See Requirements for Machinery and Engineering Systems of Unconventional Design*, Vol 2, Pt 1, Ch 5 and Risk Assessment (RA) Vol 2, Pt 1, Ch 2,17.

Volume 1, Part 1, Chapter 3
Periodical Survey Regulations

Effective date 1 January 2014

■ *Section 10*
Electrical equipment

10.1 Annual and Intermediate Surveys

10.1.1 The electrical contacts of air circuit-breakers are to be visually inspected and maintained in accordance with the manufacturer's recommendations by suitably qualified and trained personnel. Appropriate maintenance records are to be made available to the attending Surveyor on request.

Existing paragraph 10.1.1 *has been renumbered* 10.1.2.

10.2 Complete Surveys

10.2.4 Air circuit-breakers for essential or emergency services and rated at 800 A and above are to be inspected to ensure that the manufacturer's recommended number of switching options has not been exceeded. *See* Vol 2, Pt 10, Ch 1,7.3.6. Where a breaker is not fitted with an automatic counter, a written record is to be kept.

Existing paragraphs 10.2.4 *and* 10.2.5 *have been renumbered* 10.2.5 *and* 10.2.6.

~~*10.2.6*~~ *10.2.7* Where transformers associated with supplies to essential services are liquid immersed, the Owner is to arrange for samples of the liquid to be taken and tested for dissolved gases, breakdown voltage, acidity and moisture, by a competent authority, in accordance with the equipment manufacturer's requirements, and a certificate giving the test results is to be ~~furnished~~ made available to the Surveyor on request.

Existing paragraphs 10.2.7 *to* 10.2.9 *have been renumbered* 10.2.8 *to* 10.2.10.

~~*10.2.10*~~ *10.2.11* Where the ship is electrically propelled, the propulsion motors, generators, propulsion transformers, propulsion conversion equipment, cables and all ancillary electrical gear, exciters and ventilating plant (including coolers) associated therewith are to be examined, and the insulation resistance to earth is to be tested. Special attention is to be given to windings, commutators and sliprings. Where practicable, the low voltage and high voltage windings of resin coated propulsion transformers are to be subjected to boroscopic inspection. The operation of protective gear and alarm devices is to be checked, so far as is practicable. Insulating oil, if used, is to be tested in accordance with ~~10.2.6~~ 10.2.7. Interlocks intended to prevent unsafe operations or unauthorised access are to be checked to verify that they are functioning correctly. Emergency overspeed governors are to be tested.

Existing paragraph 10.2.11 *has been renumbered* 10.2.12.

Effective date 1 January 2014

■ *Section 15*
Machinery planned maintenance and condition monitoring, MPMS, MCM and RCM

15.4 Basic requirements for approval of MPMS, MCM and RCM schemes

15.4.3 The following information is to be submitted to LR for review:

(a) Hard or soft copy (with operating systems if necessary) of the studies, conducted in accordance with a relevant national or international Standard, such as ISO 17359, *Condition monitoring and diagnostics of machines – General guidelines*. This is to include~~,~~ operating context, details of study team, ~~FMECA~~ Risk Assessment (RA, *see also* Pt 1, Ch 2,17), algorithm decision sheets, summary of maintenance tasks, summary of 'level of repair analysis', identification of 'critical' spares.

(b) Details of system/equipment covered by the study.

(c) Copy of acceptance letter from equipment manufacturer confirming their review of the study details.

15.4.4 LR will verify by audit that the following items have been complied with:

(a) Study has been undertaken in full compliance of the methodology embodied in an acceptable and applicable standard for **RCM**.

(b) Study team members have adequate experience both of undertaking **RCM** studies and the systems/equipment under review.

(c) Study team members have been present during the study for sufficient time (~~%~~ percentage of total time taken) to ~~properly~~ contribute properly to the study.

(d) No 'Mandatory Redesign' requirements are outstanding.

(e) Where spares have been identified as 'Critical', they have been properly identified in the management systems on board.

(f) Procedures for collection of condition monitoring information have been established and reporting procedures for submission of this as part of the approved **MPMS** are clearly documented.

(g) Where Standard Operating Procedures have been identified, that an adequate management system is in place to ensure that they are complied with.

(h) The ~~**FMECA**~~ **RA**, *see* Vol 2, Pt 1, Ch 2,17, is in compliance with an acceptable standard, good marine engineering practice and application of valid reliability data.

Volume 1, Part 4, Chapter 1
Military Design

Effective date 1 January 2014

■ *Section 6*
Magazine design and construction

6.1 General

6.1.2 Where Naval Authority Regulations are not specified the following requirements apply. A Risk ~~assessment~~ Assessment, in accordance with Vol 2, Pt 1, Ch 2,17, may be used to justify alternative arrangements. This is to be approved by the Naval Authority or organisation acting on the Naval Authority's behalf. All recommendations and requirements are to be demonstrated to have been applied.

Volume 2, Part 1, Chapter 1
General Requirements for Classification of Engineering Systems

Effective date 1 January 2014

■ *Section 4*
Engineering system classification principles

4.5 Trials principles

4.5.4 Where a ~~FMEA~~ Risk Assessment report, (*see* Pt 1, Ch 2,17), has identified the need to prove the conclusions, testing and trials are to be carried out as necessary to investigate the following:

(a) The effect of a specific component failure.
(b) The effectiveness of automatic/manual isolation systems.
(c) The behaviour of any interlocks that may inhibit operation of essential services.

Volume 2, Part 1, Chapter 2
Requirements for Design, Construction, Installation and Sea Trials of Engineering Systems

Effective date 1 January 2014

■ *Section 3*
Particulars to be submitted

3.3 Calculations and specifications

3.3.8 ~~**Failure Mode and Effect Analysis.** An FMEA~~ A Risk Assessment (RA), in accordance with the guidance in Section 17, is to be carried out, covering the following systems:

(a) Main and auxiliary machinery systems supporting propulsion, steering or other essential services.
(b) Steering systems.
(c) Electrical generation and distribution systems supporting (a) and (b), *see* Pt 10, Ch 1,5.2.4.

This requirement is in addition to the requirements for class notations covering propulsion and steering machinery redundancy ~~and dynamic positioning~~ (*see* Volume 3), and Ship Type piping systems (*see* Pt 7, Ch 5). ~~*See* Section 17 for FMEA format requirements.~~

■ *Section 17*
~~Failure Mode and Effects Analysis (FMEA)~~ Risk Assessment (RA)

17.1 General

17.1.1 ~~An FMEA is to be~~ A Risk Assessment (RA) supported using a technique selected from IEC/ ISO 31010 *Risk Management – Risk Assessment techniques* is to be performed. The technique selected is to be carried out in accordance with the relevant International Standard or applicable National Standard and with 17.1.2 to 17.1.6 for systems (a), (b) and (c) as specified in 3.3.8. ~~The analysis is to demonstrate that suitable risk mitigation has been achieved so that the system will tolerate a single failure with regard to the criteria specified in Pt 1, Ch 1,4.2.9 and 4.2.10. The scope of analysis required for each system is defined in the respective parts of the Rules~~. A justification is to be provided which demonstrates the suitability of the Standard and analysis technique chosen.

17.1.2 ~~The FMEA is to be carried out using the format presented in Table 2.17.1 or an equivalent format that addresses the same safety issues. Analysis in accordance with IEC 60812, *Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)* or IMO MSC Resolution 36(63) Annex 4 *Procedures for Failure Mode and Effects Analysis*, would be acceptable.~~ The RA is to demonstrate that suitable risk mitigation has been achieved for all normal and reasonably foreseeable abnormal conditions. The scope of analysis required for each system is defined in 17.1.3 to 17.1.6 and in the respective parts of the Rules.

NOTE

A reasonably foreseeable abnormal condition is an event, incident or failure that :

- has happened and could happen again;
- is planned for (e.g., emergency actions cover such a situation, maintenance is undertaken to prevent it, etc.).

They should be identified by:

- using analysis processes that were capable of revealing abnormal conditions;
- employing a mix of personnel including competent safety/risk professionals and those with relevant domain knowledge and understanding to apply the processes;
- referencing relevant events and historic data; and
- documenting the results of the analysis.

17.1.3 ~~The FMEA~~ The RA is to be organised in terms of items of equipment and function. The effects of item failures or damage at stated level and at higher levels are to be analysed to determine the effects on the system as a whole. Actions for mitigation are to be determined.

17.1.4 The ~~FMEA~~ RA is to:

(a) Identify the equipment or sub-system ~~mode~~ and their modes of operation and the equipment~~.~~ ;

(b) Identify potential failure modes and damage situations and their causes~~.~~ ;

(c) Evaluate the effects on the system of each failure mode and damage situation~~.~~ ;

(d) Identify measures for reducing the risks associated with each failure mode~~.~~ ;

(e) Identify measures for failure mitigation; and

(e) (f) Identify trials and testing necessary to prove conclusions.

17.1.6 Where ~~FMEA~~ RA is used for consideration of systems that depend on software based functions for control orco-ordination, the analysis is to investigate failure of the function rather than a specific analysis of the software code.

~~Table 2.17.1 Failure mode and effects analysis~~

System				Element							
Item No.	Component description	Function	Mode of operation	Failure mode	Failure cause	Failure detection	Effect of failure		Severity	Corrective action	Remarks
							On item	On system			

NOTE
The severity category is to be in accordance with the following:
(a) Catastrophic; (b) Hazardous; (c) Major or (d) Minor.

Volume 2, Part 1, Chapter 5

Requirements for Machinery and Engineering Systems of Unconventional Design

Effective date 1 January 2014

■ *Section 1*
Requirements for machinery and engineering systems of unconventional design

1.7 Risk management

1.7.5 The procedure is to ensure that hazards are identified using acceptable and recognised hazard identification techniques, (*see* Pt 1, Ch 2,17), and that the effects of the following influences are considered:

(a) Operations that the ship is intended to perform during trials, in service, while docking and in harbour, including those related to mission specific activities and degraded and reversionary modes of operation.

(b) Ship conditions ~~during~~ under normal and reasonably foreseeable abnormal operating conditions ~~normal operations and abnormal conditions~~ arising from ~~reasonably foreseeable~~ failures or misuse of ship equipment or systems.

(c) Configurations and modes of operation provided for the intended control of machinery and engineering systems.

(d) The environmental conditions that the equipment or systems will experience due to their location within the ship and due to the geographical location in which the ship operates.

(e) The reliance and effects on the operation of engineering systems and machinery of the provision and availability of supplies and services and user interaction, including assessment of interdependencies.

(f) The environmental impact of the ship throughout its life-cycle.

1.7.6 The procedure is to ensure that risks are analysed using acceptable and recognised ~~risk analysis~~ Risk Assessment techniques, (*see* Pt 1, Ch 2,17), and that the following consequences are considered:

(a) Loss of function.

(b) Loss of services essential to the safety of the ship, services essential to the safety of shipboard personnel and services essential to the protection of the environment.

(c) Damage to components.

(d) Damage caused by fire, explosion, electric shock, harmful releases and hazardous releases.

Volume 2, Part 2, Chapter 1

Diesel Engines

Effective date 1 January 2014

■ *Section 1*
General requirements

1.1 Application

1.1.3 Primary exhaust gas emissions abatement plant (where fitted) is to meet the requirements of this Chapter; additionally, it is to meet the requirements of Part 12. Where secondary exhaust gas emissions abatement systems are fitted to engines, they are to meet the requirements of Part 12.

■ *Section 2*
Particulars to be submitted

2.1 Plans and information

2.1.4 ~~A Failure Mode and Effects Analysis (FMEA)~~ Risk Assessment (RA) as required by Pt 1, Ch 2 is to be submitted. The ~~FMEA~~ RA is to be carried out in accordance with the requirements of Pt 1, Ch 2,17 and is to include the following associated sub-systems:

- Starting and stopping.
- Oil fuel.
- Lubricating oil.
- Cooling water (fresh and sea).
- Air induction.
- Exhaust.
- Engine mounting.
- Control and monitoring.
- Electrical power supplies.
- Hydraulic oil (for valve lift).

It is not necessary to consider failure modes relating to the engine components.

Section 15
Electronically controlled engines

15.3 ~~Risk-based analysis~~ Risk Assessment (RA)

15.3.1 ~~An analysis~~ A Risk Assessment (RA) is to be carried out in accordance with the requirements of Pt 1, Ch 2,17, ~~relevant standards acceptable to LR to demonstrate compliance~~ and with the applicable requirements of this sub-Section appropriate to the engine application. The analysis is to be a risk-based consideration of engine operation and ship and personnel safety, and is to demonstrate adequate risk mitigation through fault tolerance and/or reliability in accordance with the specified criteria in 15.3.2 to 15.3.4, relevant to the engine application.

15.3.2 For ships with a single main propulsion engine, a ~~Failure Mode and Effects Analysis (FMEA),~~ RA of system reliability, in accordance with Pt 1, Ch 2,17, ~~or alternative recognised analysis of system reliability,~~ is to be carried out and is to demonstrate that an electronic control system failure:

(a) will not result in the loss of the ability to provide the services essential for the operation of the engine, *see* Pt 9, Ch 1,2.5.7 and 2.13.2;
(b) will not affect the normal operation of the services essential for the operation of the engine other than those services dependent upon the failed part, *see* Pt 9, Ch 1,2.14.4 and 2.14.5; and
(c) will not leave either the engine, or any equipment or machinery associated with the engine, or the ship in an unsafe condition, *see* Pt 9, Ch 1,2.3.15, 2.4.5, 2.5.4, 2.10.3, 2.10.4 and 2.14.5.

15.3.3 A ~~risk-based analysis~~ RA is to be carried out for:

(a) main engines on ships with multiple main engines or other means of providing propulsion power; and/or
(b) auxiliary engines intended to drive electric generators forming the ship's main source of electrical power or otherwise providing power for essential services.

The ~~analysis~~ RA is to demonstrate that adequate hazard mitigation has been incorporated in electronically controlled engine systems or the overall ship installation, with respect to personnel safety and providing propulsion power and/or power for essential services for the safety of the ship. Arrangements satisfying the criteria of 15.3.2(a) to (c) will also be acceptable.

15.3.4 For engines for emergency power purposes, a ~~risk-based analysis~~ RA is to be carried out to demonstrate that the design incorporates adequate hazard mitigation, such that the likelihood of an electronic engine system failure resulting in the loss of the ability to provide emergency power has been reduced to a level considered acceptable by LR, and that means are provided to detect failures and permit personnel to restore engine availability to operate on demand. Failures which would result in engine failure and/or damage or loss of availability are to be identified and the report is to include documentation of:

(a) component reliability evidence;
(b) failure detection and alarms; and
(c) failure response required to restore engine availability and maintain personnel safety.

15.3.5 The ~~risk-based analysis~~ RA report is to:

(a) Identify the standards used for analysis and system design.
(b) Identify the engine, its purpose and the associated objectives of the analysis.
(c) Identify any assumptions made in the analysis.
(d) Identify the equipment, system or sub-system, mode of operation and the equipment.
(e) Identify potential failure modes and their causes.
(f) Evaluate the local effects (e.g., fuel injection failure) and the effects on the system as a whole (e.g., loss of propulsion power) of each failure mode.
(g) Identify measures for reducing the risks associated with each failure mode (e.g., system design, failure detection and alarms, redundancy, quality control procedures for sourcing, manufacture and testing, etc.).
(h) Identify trials and testing necessary to prove conclusions.

15.3.7 Where emergency engines are used as harbour sets, the system is to comply with the requirements of Pt 10, Ch 1,3.2.6. This function is to be included in the ~~risk-based analysis~~ RA.

Volume 2, Part 2, Chapter 2
Gas Turbines

Effective date 1 January 2014

■ *Section 2*
Particulars to be submitted

2.1 Plans and information

2.1.4 A ~~Failure Mode and Effects Analysis (FMEA)~~ Risk Assessment (RA) as required by Pt 1, Ch 2 is to be submitted. The ~~FMEA~~ RA is to be carried out in accordance with the requirements of Pr 1, Ch 2,17 and is to include the following associated sub-systems:

- Starting and stopping.
- ~~Oil fuel~~ Fuel.
- Lubricating oil.
- Hydraulic oil.
- Wet washing arrangements.
- Cooling ~~water~~ arrangements.
- Intercooler, where applicable.
- Air induction.
- Exhaust.
- Recuperator, where applicable.
- Gas turbine mounting.
- Electrical power supplies.
- Control and monitoring systems.
- Safety systems.
- Ventilation.
- Fire protection (where applicable).
- Rotor turning arrangements.
- ~~Electrical power supplies.~~

It is not necessary to consider failure modes relating to the components within the gas turbine ~~components~~ unit for the purposes of this ~~clause~~ paragraph.

Volume 2, Part 2, Chapter 3
Steam Turbines

Effective date 1 January 2014

■ *Section 1*
General requirements

1.1 Application

1.1.3 Where exhaust gas emissions abatement equipment is fitted to steam-raising plant, it is to meet the requirements of Part 12.

Volume 2, Part 3, Chapter 1
Gearing

Effective date 1 January 2014

■ *Section 5*
Plans and particulars to be submitted

5.3 Design data and calculations

5.3.2 A ~~Failure Mode Effects Analysis (FMEA)~~ Risk Assessment (RA) as required by Pt 1, Ch 2 is to be submitted. The ~~FMEA~~ RA is to be carried out in accordance with the requirements of Pt 1, Ch 2,17 and is to include the following associated sub-systems:

- Clutches.
- Flexible couplings.
- Lubricating oil.
- Cooling arrangements.
- Dehumidification.
- Gearbox mounting.
- Control and monitoring.
- Electrical power supplies.

It is not necessary to consider failure modes relating to the gearbox components.

Volume 2, Part 3, Chapter 2
Shafting Systems

Effective date 1 January 2014

■ *Section 2*
Particulars to be submitted

2.1 Plans

2.1.3 A ~~Failure Mode and Effects Analysis (FMEA)~~ Risk Assessment (RA) as required by Pt 1, Ch 2 is to be submitted. The ~~FMEA~~ RA is to be carried out in accordance with the requirements of Pt 1, Ch 2,17 and is to include the following associated sub-systems:

Clutches.
Flexible couplings.
Lubrication.
Cooling arrangements.
Bearing mountings.
Control and monitoring.
Electrical power supplies.
Thrust blocks.

It is not necessary to consider failure modes relating to the shafting components.

Volume 2, Part 4, Chapter 2

~~Waterjet~~ Water Jet Systems

Effective date 1 January 2014

■ *Section 2*
General requirements

2.1 Water jet arrangements

2.1.1 In general, for a ship to be assigned an unrestricted service notation, a minimum of two water jet systems is to be provided where these form the sole means of propulsion. For ships where a single water jet system is the sole means of propulsion or steering, a detailed engineering and safety justification is to be evaluated by LR, *see* 2.3.22. This evaluation process will include a ~~risk assessment analysis, using a recognised technique,~~ Risk Assessment (RA) in accordance with Pt 1, Ch 2,17, to verify that sufficient levels of redundancy and monitoring are incorporated in the water jet unit's essential support systems and operating equipment.

2.3 Calculations and information

2.3.23 Where an engineering and safety justification report is required, the following supporting information is to be submitted:

- A ~~Failure Mode and Effects Analysis report (FMEA)~~ Risk Assessment (RA), *see* 2.4.
- Design standards and assumptions.
- Limiting operating parameters.
- A statement and evidence in respect of the anticipated reliability of any non-duplicated components.

2.4 ~~Failure Mode and Effects Analysis (FMEA)~~ Risk Assessment (RA)

2.4.1 ~~An FMEA~~ A Risk Assessment in accordance with Pt 1, Ch 2,17 is to be carried out where a single water jet system is the ship's sole means of propulsion, *see* 2.2.3. The ~~FMEA~~ RA is to identify components where a single failure could cause the loss of all propulsion and/or steering capability and the proposed arrangements for preventing and mitigating the effects of such a failure.

~~*2.4.2* The FMEA is to be carried out using the format presented in Table 2.17.1 in Pt 1, Ch 2,17 or an equivalent format that addresses the same reliability issues. Analyses in accordance with IEC 60812 *Analysis for System Reliability – Procedures for Failure Mode and Effects Analysis*, or the IMO *Code of Safety for High Speed Craft, 2000, Annex 4 – Procedures for Failure Mode and Effects Analysis*, would be acceptable.~~

~~*2.4.3* The FMEA is to be organised in terms of equipment and function. The effects of item failures at a stated level and at higher levels are to be analysed, to determine these effects on the system as a whole. Actions for mitigation of the effects of failure are to be determined, *see* 2.4.1.~~

~~*2.4.4* The FMEA is to:~~

~~(a) identify the equipment or sub-system and mode of operation;~~
~~(b) identify potential failure modes and their causes;~~
~~(c) evaluate the effects on the system of each failure mode;~~
~~(d) identify measures for reducing the risks associated with each failure mode;~~
~~(e) identify measures for preventing failure; and~~
~~(f) identify trials and testing necessary to prove conclusions.~~

~~*2.4.5* At sub-system level it is acceptable, for the purposes of these Rules, to consider failure of equipment items and their functions. It is not required that the failure of components within that equipment item be analysed, *see* Pt 1, Ch 2,17.1.5.~~

~~*2.4.6* Where an FMEA is used for consideration of systems that depend on software-based functions for control or co-ordination, the analysis is to investigate failure of the functions rather than a specific analysis of the software code itself.~~

■ *Section 3*
Design requirements

3.6 Tunnel and securing arrangements

3.6.1 The tunnel is to be adequately supported, framed and fully integrated into the hull structure. The critical locations and integrity of the supports and framing are to be as specified in the ~~FMEA~~ Risk Assessment, *see* 2.4.1, and agreed by the Shipbuilder and LR.

3.7 Nozzle/steering arrangements

3.7.1 In general, the steering systems and components are to comply with the requirements of Pt 6, Ch 1. The requirements of Pt 6, Ch 1,4.1.2(b) and (c) are addressed by 3.7.3 and the requirements of Pt 6, Ch 1,4.1.3(b) and (c) are addressed by 3.7.4.

3.7.2 For vessels with more than one steerable water jet, the requirement for auxiliary steering arrangements in Pt 6, Ch 1 is to be achieved by equipping each of the steerable water jets with its own dedicated and independent steering gear control system and power actuating system. Consideration will be given to alternative arrangements providing equivalence can be demonstrated.

3.7.3 The main steering arrangements are to be operated by power and capable of changing the direction of the ship's water jet nozzles from one side to the other at declared steering angle limits, at an average rotational speed of not less than 0,4 rev/min with the ship running ahead at maximum ahead service speed.

3.7.4 The auxiliary steering arrangements are to be:

(a) Capable of changing the direction of the ship's water jet nozzles from one side to the other at declared steering angle limits at an average rotational speed of not less than 0,083 rev/min, with the ship running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater.

(b) Operated by power for ships having propulsion power of more than 2500 kW per water jet unit and for all ships, where it is necessary, to meet the requirements of (a).

Existing paragraphs 3.7.2 *to* 3.7.5 *have been renumbered* 3.7.5 *to* 3.7.8.

3.8 Bolts

3.8.1 Detailed consideration and analysis are to be given to essential bolting arrangements in critical locations, as specified in the ~~FMEA~~ Risk Assessment, *see* 2.4.1, and where indicated by the manufacturer or Shipbuilder and agreed by LR. These are to include bolts used in the securing of blades or guide vanes, assembly of the unit in the ship and any conduit components.

■ *Section 7* Inspection, testing and fitting of water jets

7.1 General

7.1.3 Bolts and nuts in critical locations, as specified in the ~~FMEA~~ Risk Assessment, *see* 2.4.1 and, where indicated by the manufacturer or Shipbuilder and agreed by LR, are to be equipped with adequate securing arrangements to the satisfaction of the LR Surveyor.

7.3 Sea trial requirement

7.3.4 Any trials and testing identified from the ~~FMEA~~ Risk Assessment report~~, *see* 2.4.4~~ are to be carried out, *see* Pt 1, Ch 2,17.

Volume 2, Part 4, Chapter 3
Thrusters

Effective date 1 January 2014

■ *Section 1* General requirements

1.2 Redundancy

1.2.2 For vessels with multiple azimuthing thrusters, the requirement for auxiliary steering arrangements in Pt 6, Ch 1,4 is to be achieved by equipping each of the azimuthing thrusters with its own dedicated and independent steering gear control system and power actuating system. Consideration will be given to alternative arrangements providing equivalence can be demonstrated.

Existing paragraph 1.2.2 *has been renumbered* 1.2.3.

■ *Section 4* Design and construction

4.1 General

(*Part only shown*)

4.1.3 In addition to the requirements of this Section, reference is to be made to:

(f) Steering arrangements, Pt 6, Ch 1.

4.2 Azimuth thrusters

(*Part only shown*)

4.2.1 The following requirements are to be complied with:

~~(a) The azimuthing mechanism is to be capable of a maximum rotational speed of not less than 1,5 rev/min.~~

(a) In general, the steering systems and components are to comply with the requirements of Pt 6, Ch 1. The requirements of Pt 6, Ch 1,4.1.2(b) and (c) are addressed by 4.2.1(c) and the requirements of Pt 6, Ch 1,4.1.3(b) and (c) are addressed by 4.2.1(d).

(b) The steering arrangements for azimuthing thrusters used for dynamic positioning applications with an associated class notation are to be capable of a maximum rotational speed of not less than 1,5 rev/min.

(c) The main steering arrangements are to be operated by power and capable of changing the direction of the ship's azimuth thrusters from one side to the other at declared steering angle limits, at an average rotational speed of not less than 0,4 rev/min with the ship running ahead at maximum ahead service speed.

(d) The auxiliary steering arrangements are to be:

  (i) Capable of changing the direction of the ship's azimuth thrusters from one side to the other at declared steering angle limits at an average rotational speed of not less than 0,083 rev/min with the ship running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater.

  (ii) Operated by power for ships having propulsion power of more than 2500 kW per thruster unit and for all ships, where it is necessary, to meet the requirements of (a).

Existing (b) *to* (f) *have been renumbered* (e) *to* (j).

Volume 2, Part 4, Chapter 4
Podded Propulsion Units

Effective date 1 January 2014

■ *Section 2*
General requirements

2.1 Pod arrangement

2.1.1 In general, for a ship to be assigned an unrestricted service notation, a minimum of two podded propulsion units ~~are~~ is to be provided where these form the sole means of propulsion. For vessels where a single podded propulsion unit is the sole means of propulsion, an evaluation of a detailed engineering ~~and safety~~ justification will be conducted by LR, *see* 2.2.2. This evaluation process will include the appraisal of a ~~Failure Modes and Effects Analysis (FMEA)~~ Risk Assessment (RA) to verify that sufficient levels of redundancy and monitoring are incorporated in the podded propulsion unit's essential support systems and operating equipment.

2.2 Plans and information to be submitted

2.2.2 Where an engineering ~~and safety~~ justification report is required, the following supporting information is to be submitted:

- ~~A Failure Mode and Effects Analysis (FMEA), *see* 2.5.~~ A Risk Assessment (RA) in accordance with Pt 1, Ch 2,17 is to be carried out, *see* 2.1.1. The RA is to identify components where failure could cause loss of all propulsion, steering capability or other essential services, and the proposed arrangements for preventing and mitigating the effects of such a failure.
- Design standards and assumptions.
- Limiting operating parameters.
- A statement and evidence in respect of the anticipated reliability of any ~~non-duplicated~~ components.

~~2.5 Failure Modes and Effects Analysis (FMEA)~~

~~*2.5.1* An FMEA is to be carried out where a single podded propulsion unit is the vessel's sole means of propulsion, *see* 2.1.1. The FMEA is to identify components where a single failure could cause loss of all propulsion and/or steering capability and the proposed arrangements for preventing and mitigating the effects of such a failure. The assessment required by Pt 10, Ch 1,16.2.2 may be considered for demonstrating the acceptability of the proposed design for propulsion power purposes.~~

~~*2.5.2* The FMEA is to be carried out using the format presented in Table 2.17.1 in Pt 1, Ch 2 or an equivalent format that addresses the same reliability issues. Analyses in accordance with IEC 60812, *Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)*, or IMO MSC Resolution 36(63) Annex 4 – *Procedures for Failure Mode and Effects Analysis*, would be acceptable.~~

~~*2.5.3* The FMEA is to be organised in terms of equipment and function. The effects of item failures at a stated level and at higher levels are to be analysed to determine the effects on the system as a whole. Actions for mitigation of the effects of failure are to be determined, *see* 2.5.1.~~

~~*2.5.4* The FMEA is to:~~

- ~~(a) identify the equipment or sub-system and mode of operation;~~
- ~~(b) identify potential failure modes and their causes;~~
- ~~(c) evaluate the effects on the system of each failure mode;~~
- ~~(d) identify measures for reducing the risks associated with each failure mode;~~
- ~~(e) identify measures for preventing failure; and~~
- ~~(f) identify trials and testing necessary to prove conclusions.~~

~~*2.5.5* At sub-system level it is acceptable, for the purpose of these Rules, to consider failure of equipment items and their functions, e.g., failure of a pump to produce flow or pressure head. It is not required that the failure of components within that pump be analysed. In addition, their failure need only be dealt with as a cause of failure of the pump.~~

~~*2.5.6* Where FMEA is used for consideration of systems that depend on software-based functions for control or co-ordination, the analysis is to investigate failure of the functions rather than a specific analysis of the software code itself.~~

Existing sub-Section 2.6 *has been renumbered* 2.5.

■ *Section 3*
Functional capability

3.1 General

3.1.2 ~~In general, the steering mechanism is to be capable of turning the pod between the~~ The main steering arrangements are to be operated by power and capable of changing the direction of the ship's podded propulsion units from one side to the other at declared steering angle limits at an average rotational speed of not less than 0,4 rev/min with the ship initially operating at its maximum ahead service speed.

3.1.4 The auxiliary steering arrangements are to be:

- (a) Capable of changing the direction of the ship's podded propulsion units from one side to the other at declared steering angle limits at an average rotational speed of not less than 0,083 rev/min, with the ship running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater.
- (b) Operated by power for ships having propulsion power of more than 2500 kW per podded propulsion unit and for all ships, where it is necessary, to meet the requirements of (a).

■ *Section 6*
Machinery design and construction requirements

6.6 Steering system

6.6.1 The requirements of Pt 6, Ch 1, Sections 1, 2, 3, 4, 5, 8 and 9 are to be complied with where applicable. *See also* 3.1. The requirements of Pt 6, Ch 1,4.1.2(b) and (c) are addressed by 3.1.2 and the requirements of Pt 6, Ch 1,4.1.3(b) and (c) are addressed by 3.1.4.

6.6.2 For vessels where a single podded propulsion unit is the sole means of propulsion, the requirement for auxiliary steering ~~gear~~ arrangements in Pt 6, Ch 1,4 is to be achieved by means of two or more identical power units.

6.6.3 For vessels with more than one steerable podded propulsion unit, the requirement for auxiliary steering arrangements in Pt 6, Ch 1,4 is to be achieved by equipping each of the podded propulsion units with its own dedicated and independent steering gear control system and power actuating system. Consideration will be given to alternative arrangements, providing equivalence can be demonstrated.

Existing paragraphs 6.6.3 *to* 6.6.8 *have been renumbered* 6.6.4 *to* 6.6.9.

■ *Section 8*
Control engineering arrangements

8.1 General

8.1.5 ~~Means~~ Emergency Stop Functions are to be provided at the remote control station(s), independent of the podded drive control system, to stop each podded drive in an emergency, *see also* Pt 10, Ch 1,16.4.7.

■ *Section 9*
Testing and trials

9.1 General

9.1.4 Any trials and testing identified from the ~~FMEA~~ Risk Assessment report, *see* ~~2.5.4(f)~~ Pt 1, Ch 2,17, are also to be carried out.

Volume 2, Part 6, Chapter 1
Steering ~~Gear~~ Arrangements

Effective date 1 January 2014

■ *Section 1*
General requirements

1.1 Application

1.1.1 The requirements of this Chapter apply to the design and construction of steering ~~gear~~ arrangements and are to be read in conjunction with the requirements for Machinery and Engineering Systems in Pt 1, Ch 1 and Ch 2.

1.2 Definitions

1.2.9 **Steering arrangements** means the complete system of components for providing ship directional control.

1.2.10 **Directional control system** means the equipment used to effect changes in ship direction, e.g., the rudder, podded propulsion unit, azimuth thrusters or water jet nozzle. Note that for podded propulsion systems, azimuth thrusters, water jet systems, or other similar systems for effecting changes in ship direction, it is to be assumed that the units must provide thrust in addition to rotation and hence the directional control system must include the propulsion system.

■ *Section 2*
Particulars to be submitted

2.3 Calculations and information

2.3.4 A ~~Failure Mode and Effects Analysis (FMEA)~~ Risk Assessment (RA) as required by Pt 1, Ch 2 is to be submitted. The ~~FMEA~~ RA is to be in accordance with Pt 1, Ch 2,17, is to address the steering system and is to include the following associated sub-systems:

- Hydraulic.
- Securing/mounting.
- Control and monitoring.
- Electrical power supplies.

It is not necessary to consider failure modes relating to the steering gear components.

■ *Section 3*
Materials

3.1 General

3.1.1 All ~~the steering gear~~ components used in steering arrangements for ship directional control are to be of sound reliable construction to the Surveyor's satisfaction.

■ *Section 4* Performance

4.1 General

4.1.1 Unless the main steering ~~gear~~ arrangements for ship directional control comprise~~s~~ two or more identical power units, in accordance with 4.1.4, every ship is to be provided with ~~a~~ main steering ~~gear~~ arrangements and ~~an~~ auxiliary steering ~~gear~~ arrangements in accordance with the requirements of the Rules. The main ~~steering gear~~ and ~~the~~ auxiliary steering ~~gear is~~ arrangements are to be so arranged that the failure of one of them will not render the other one inoperative.

(*Part only shown*)
4.1.2 The main steering ~~gear and rudder stock is~~ arrangements for ship directional control are to be:

(*Part only shown*)
4.1.3 The auxiliary steering ~~gear is~~ arrangements for ship directional control are to be:

4.1.4 Where the main steering ~~gear~~ arrangements for ship directional control comprise~~s~~ two or more identical power units, ~~an~~ auxiliary steering ~~gear~~ arrangements need not be fitted, provided that the main steering ~~gear is~~ arrangements are capable of operating the ~~rudder~~ ship's directional control system as required by 4.1.2(b) while any one of the power units is out of operation.

4.1.6 Where the steering ~~gear is so arranged~~ arrangements are such that more than one power or control system can be simultaneously operated, the risk of hydraulic locking caused by a single failure is to be considered.

■ *Section 7* Electrical power circuits and equipment

7.1 Electric power circuits, electric control circuits, monitoring and alarms

7.1.2 Where steering gear motor circuits are supplied by converters, consideration will be given to arrangements that provide an equivalent level of safety, reliability, availability and indication to those specified in 7.1.1, provided that a technical justification is submitted.

Existing paragraphs 7.1.2 *to* 7.1.10 *have been renumbered* 7.1.3 *to* 7.1.11.

■ *Section 9* Alternative sources of power and emergency operation

9.1 Alternative sources of power

9.1.1 An alternative power supply, sufficient to supply the steering ~~gear power unit that complies~~ arrangements which comply with the requirements of 4.1.2 and also its associated control systems and ~~rudder angle~~ steering angle indicator, is to be provided automatically, within 45 seconds of loss of the main power supply, either from an emergency or alternative source of electrical power complying with Pt 10, Ch 1,3 or from an independent source of power located in the steering gear compartment. Where an independent source of electrical power located in the steering gear compartment is used as an alternative power supply, this source is to be used only for this purpose.

Volume 2, Part 7, Chapter 1
Piping Design Requirements

Effective date 1 January 2014

■ *Section 1* Scope

1.1 Application

1.1.5 Piping design is to comply with the remainder of this Chapter, as applicable.

■ *Section 4* Materials

4.1 Metallic materials

4.1.4 The Manufacturer's materials certificate ~~validated by LR~~ will be accepted for Class III piping systems and for all other classes of piping and associated components in lieu of an LR materials certificate where either of the maximum design conditions ~~are~~ is less than ~~either of~~ the values shown in Table 1.4.1. *See* Ch 1,3.1.3~~(b)~~(c) of the Rules for Materials.

■ *Section 5*
Pipe connections

5.10 Mechanical connections for piping

5.10.13 Mechanical joints are to be tested in accordance with a program approved by LR, which is to include the following tests as relevant to the service conditions and the intended application:

- leakage test;
- vacuum test;
- vibration (fatigue) test;
- fire endurance test;
- burst pressure test;
- pressure pulsation test;
- reassembly test;
- pull-out test;
- static displacement/misalignment test.

■ *Section 11*
Plastics pipe connections

11.1 General

11.1.8 Where it is proposed to use plastics materials for piping systems and associated equipment installed in naval ships, the Naval Authority may require a ~~risk assessment~~ Risk Assessment, in accordance with Pt 1, Ch 2,17, to be submitted that addresses the following:

(a) the potential fire risks in the space containing the plastics materials;

(b) The effect of a fire in the compartment containing plastics materials in terms of fire spread and of producing excessive quantities of smoke and toxic products.

(c) An engineering justification for the use of plastics materials in preference to metallic materials which are not sensitive to heat.

Volume 2, Part 7, Chapter 2
Ship Piping Systems

Effective date 1 January 2014

■ *Section 1*
General requirements

1.2 Plans and particulars

(*Part only shown*)

1.2.1 At least three copies of the following plans (in diagrammatic form) and particulars are to be submitted for approval. Additional plans should not be submitted unless the arrangements are of a novel or special character affecting classification:

- Ballast filling and drainage arrangements. The submission should include a schematic piping drawing showing connection of the ballast water treatment system, where fitted, to the ballast filling and drainage arrangement.

■ *Section 11*
Ballast system

11.1 General

11.1.1 Any deck and bulkhead penetrations shall meet the requirements of Ch 2,1.

11.1.2 There shall be no transfer of ballast water from hazardous areas to non-hazardous areas.

11.1.3 Where transfer of ballast water from non-hazardous to hazardous areas is required, connection between the areas is to be non-permanent. Such non-permanent connections are to be in accordance with the Rules for Ships, Pt 5, Ch 15,2.

11.2 Standby arrangements for ballast pumping

11.2.1 Where ballasting/de-ballasting is required for ship operation, standby ballast pumping arrangements are to be provided, *see also* 6.2.1.

11.3 Integrated cargo and ballast systems

11.3.1 Controls used for stopping the cargo system, including normal controls, safety shut-downs and Emergency Stop Functions as defined by Pt 9, Ch 1,1.5, shall not stop operation of the ballast system. All control systems shall, as a minimum, meet the applicable requirements of Pt 9, Ch 1, Sections 1, 2, 3 and 7.

11.3.2 Where **UMS**, **CCS** or **ICC** notations are applied, the control systems shall also meet the requirements of Pt 9, Ch 1, Sections 4, 5 and 6 respectively and the further applicable requirements of Pt 9, Ch 1,7.

11.4 Ballast water treatment system installations

11.4.1 Failure of a ballast water treatment system shall not impair or restrict ballasting or de-ballasting operations.

11.4.2 Failure of a ballast water treatment system shall not impair or restrict any other essential piping system, as defined by Ch 1,2.2.1, or any other essential system as defined by Pt 10, Ch 1,1.5.

11.4.3 Ballast water treatment systems are to be installed with a by-pass arrangement, designed to ensure that the treatment system can be efficiently isolated from the ballast water system without impairing ballast water flow.

11.4.4 All piping and components as defined in Ch 1,2.2.3 and forming part of the ballast water treatment system shall meet the requirements of Chapter 1.

11.4.5 All electrical equipment forming part of ballast water treatment units shall meet the applicable requirements of Pt 10, Ch 2. All control equipment forming part of the ballast water treatment units shall meet the applicable requirements of Pt 9, Ch 2. Hazardous areas associated with ballast water treatment system installations are to be determined in accordance with the requirements of Pt 10, Ch 1,14.

Volume 2, Part 7, Chapter 3
Machinery Piping Systems

Effective date 1 January 2014

■ *Section 5*
Steam piping systems

5.2 Drainage

5.2.3 For the drainage of boiler and exhaust gas economiser safety valves, *see* Pt 8, Ch 1,15.2.8 and 15.2.9.

■ *Section 11*
Electrical equipment cooling arrangements

11.1 General

11.1.10 ~~An FMEA~~ A Risk Assessment (RA) is to be carried out for the cooling arrangements for electrical equipment used in Mobility and Ship Type category systems. The analysis is to be in accordance with Pt 1, Ch 2,17 and is to address the effects of failure of cooling supplies related to the ability of equipment and systems to operate with short-term loss of cooling and to operate with any reduced standby cooling capability.

Volume 2, Part 7, Chapter 5
Ship Type Piping Systems

Effective date 1 January 2014

■ *Section 1*
General requirements

1.3 Plans and information

1.3.5 ~~**Failure Mode and Effects Analysis (FMEA).**~~ **Risk Assessment (RA).** For Ship Type piping systems with associated electrical power supplies and control systems, the ~~FMEA~~ RA report is to address the requirements in Section 5.

1.3.6 **Testing and trials procedures**. A schedule of testing and trials to demonstrate that systems are capable of operating as described in Section 3. Testing and trials procedures are to comply with 6.3.1. In addition, any testing programme that may be necessary to prove the conclusions of the ~~FMEA~~ RA, *see* 6.3.2.

1.3.7 **Operating Manuals**. Operating Manuals are to be provided on board and submitted for information where requested by LR. The Manuals are to include the following information:

(a) Particulars and a description of each system.
(b) Operating instructions for all systems.
(c) Procedures for dealing with the situations identified in the ~~FMEA~~ RA report.

Section 5
~~Failure Mode and Effects Analysis~~ Risk Assessment (RA)

5.1 General

5.1.1 ~~An FMEA~~ A Risk Assessment in accordance with Pt 1, Ch 2,17 is to be carried out ~~in accordance with 5.1.2 to 5.1.7,~~ for piping systems, electrical power supplies and control systems to demonstrate that ~~a single failure or damage in these systems will not cause loss~~ suitable risk mitigation has been achieved, for all normal and foreseeable abnormal conditions which could lead to a loss of all system capability.

~~*5.1.2* The FMEA is to be carried out using the format presented in Table 5.5.1 or an equivalent format that addresses the same safety issues. Analysis in accordance with IEC 812, *Analysis for System Reliability – Procedures for Failure Mode and Effects Analysis*, would be acceptable.~~

~~*5.1.3* The FMEA is to be organised in terms of items of equipment and function. The effects of item failures or damage at stated level and at higher levels are to be analysed to determine the effects on the system as a whole. Actions for mitigation are to be identified.~~

~~*5.1.4* The FMEA is to:~~

~~(a) Identify the equipment or sub-system, mode of operation and the equipment.~~

~~(b) Identify potential failure modes and damage situations and their causes.~~

~~(c) Evaluate the effects on the system of each failure mode and damage situation.~~

~~(d) Identify measures for reducing the risks associated with each failure mode and damage situation.~~

~~(e) Identify trials and testing necessary to prove conclusions.~~

~~*5.1.5* At sub-system level it is acceptable, for the purpose of this Chapter, to consider failure or damage of equipment items and their functions, e.g., failure of a pump to produce flow or pressure head. It is not required that the failure of components within that pump be analysed. In addition, failure need only be dealt with as a cause of failure of the pump.~~

~~*5.1.6* Where FMEA is used for consideration of systems that depend on software based functions for control or co-ordination, the analysis is to investigate failure of the function rather than the software code.~~

~~*5.1.7*~~ *5.1.2* The ~~FMEA~~ RA is to establish that the system retains a level of operational capability as defined in the design statement required by 1.3.2, following failure or damage of pipework, an item of equipment or the loss of a compartment.

Section 6
Testing and trials

6.3 Trials

6.3.2 Where the ~~FMEA~~ Risk Assessment (RA) report has identified the need to prove the conclusions, testing and trials are to be carried out as necessary to investigate the following:

(a) The effect of a specific component failure or damage situation.

(b) The effectiveness of automatic/manual isolation systems.

(c) The effectiveness of reconfiguration arrangements.

(d) The behaviour of any interlocks that may inhibit operation of other systems.

~~Table 5.5.1 Failure Mode and Effects Analysis~~

System				Element							
Item No.	Component description	Function	Mode of Operation	Failure Mode or Damage	Failure Cause	Failure Detection	Effect of Failure or Damage		Severity	Corrective Action	Remarks
							On Item	On System			

NOTE
The severity category is to be in accordance with the following:
(a) Catastrophic; (b) Hazardous; (c) Major; or (d) Minor.

Volume 2, Part 8, Chapter 1
Steam Raising Plant and Associated Pressure Vessels

Effective date 1 January 2014

■ *Section 15*
Mountings and fittings for cylindrical and vertical boilers, steam generators, pressurised thermal liquid and pressurised hot water heaters

15.2 Safety valves

15.2.8 ~~Each safety valve chest is to be drained by a pipe fitted to the lowest part and led with a continuous fall to the bilge or to a tank, clear of the boilers. No valves or cocks are to be fitted to these drain pipes. The bore of the drain pipes is to be not less than 19 mm.~~ For each safety valve, an individual unrestricted drain is to be provided. The drain pipe is to be fitted to the lowest part of the safety valve chest and is to be independently led with a continuous fall to a place where the high temperature steam and/or condensate can discharge, visibly clear of the boilers, and where it cannot cause injury. No valves or cocks are to be fitted to these drain pipes. The bore of the drain pipes is not to be less than 19 mm.

Volume 2, Part 9, Chapter 1
Control Engineering Systems

Effective date 1 January 2014

■ *Section 1*
General engineering systems

1.1 General requirements

1.1.8 LR will be prepared to give consideration to special cases or to arrangements which are equivalent to the Rules where sufficient technical justification is provided.

1.2 Plans and information

1.2.6 **Programmable electronic systems.** (In addition to the documentation required by 1.2.2.)
(a) System requirements specification.
(b) Details of the hardware configuration in the form of a system block diagram, including input/output schedules.
(c) Details of power supply and data storage arrangements, *see* 2.10.9 and 2.13.6.
(d) Hardware certification details, *see* 2.10.5 and 2.13.3.
(e) Software quality plans, including applicable procedures, *see* 2.10.20.
(f) Factory acceptance, integration, harbour and sea trial test schedules for hardware and software.
(g) System integration plan, *see* 2.14.2.
(h) ~~Failure Mode and Effects Analysis (FMEA)~~, Risk Assessment (RA), *see* 2.14.5 and Pt 1, Ch 2,17.

1.5 Definitions

1.5.1 An Emergency Stop (E-Stop) is a safeguard instigated by a single human action. It requires a stop of all movement within the controlled system as rapidly as possible to prevent a hazard occurring or to reduce an existing hazard to persons, machinery or the vessel.

1.5.2 An Emergency Trip (E-Trip) is a safeguard instigated by a single human action and means the disconnection of fuel, electrical, hydraulic or other power source from the controlled system to prevent a hazard occurring or to reduce an existing hazard to persons, machinery or the vessel. Movement within the system may be allowed to continue.

1.5.3 An Emergency Stop Function may be either an Emergency Stop or Emergency Trip, as appropriate to the system and risk being controlled.

Section 2
Essential features for control, alarm and safety systems

2.8 Fire detection alarm systems

~~*2.8.1* Where an automatic fire detection system is to be~~ fitted in a machinery space, the requirements of 2.8.2 to 2.8.13 are to be satisfied.

2.8.2 A fire detection control unit is to be located in the navigating bridge area, the fire control station, or in some other position such that a fire in the machinery spaces will not render it inoperable.

2.8.3 Fire detection indicating panels are to denote the section in which a detector or manually operated call point has operated. At least one indicating panel is to be so located on the navigating bridge unless specified otherwise by the Naval Authority.

2.8.4 An audible fire-alarm is to be provided having a characteristic tone distinguishing it from the alarm system required by 2.3 or any other alarm system. The audible fire-alarm is to be immediately audible throughout the machinery spaces, the navigating bridge and at manned watch positions as designated by the Naval Authority. Facilities are to be provided in the fire detection system to manually initiate the fire alarm from positions adjacent to all exits from machinery spaces, the navigating bridge and manned watch positions as designated by the Naval Authority.

2.8.5 The alarm system is to be designed with self-monitoring properties. Power or system failures are to initiate an audible alarm distinguishable from the fire alarm. This alarm may be incorporated in the machinery alarm system as required by 2.3.

2.8.6 For electrical engineering requirements, *see* Pt 10, Ch 1,17.1.

2.8.7 Fire detection control units (including addressable systems), indicating panels, detector heads, manual call points and short circuit isolation units are to be Type Approved in accordance with Test Specification Number 1 given in LR's Type Approval System for an environmental category appropriate for the locations in which they are intended to operate. For addressable systems, *see also* 2.10.

2.8.8 Detector heads are to be located in the machinery spaces so that all potential fire outbreak points are guarded. A combination of detectors is to be provided in order that the system will react to all possible fire characteristics.

2.8.9 When fire detectors are provided with means to adjust their sensitivity, the arrangements are to be such that the set point can be fixed and readily identified.

~~*2.8.10* When it is intended that a particular loop is to be temporarily switched off, this state is to be clearly indicated at the fire detection indicating panels.~~

~~*2.8.11* When it is intended that a particular detector(s) is (are) to be temporarily switched off locally, this state is to be clearly indicated at the local position. Reactivation of the detector(s) is to be performed automatically after a preset time.~~

~~*2.8.12* The fire detector heads are to be of a type which can be tested and reset without the renewal of any component. Facilities are to be provided on the fire control panel for functional testing and reset of the system.~~

~~*2.8.13* It is to be demonstrated to the Surveyor's satisfaction that detector heads are so located that air currents will not render the system ineffective at sea and in port.~~

2.8.1 Fire detection and fire alarm systems are to comply with Chapter 9 of the *Fire Safety Systems Code (FSS)* and 2.8.2 to 2.8.22 as applicable.

2.8.2 For electrical engineering requirements, *see* Pt 10, Ch 1.

2.8.3 Fire detection control units, indicating panels, detector heads, manual call points and short-circuit isolation units are to be Type Approved in accordance with Test Specification Number 1 given in LR's Type Approval System for an environmental category appropriate for the locations in which they are intended to operate. For addressable systems, *see also* 2.10.

2.8.4 An audible fire-alarm is to be provided having a characteristic tone distinguishing it from the alarm system required by 2.3 or any other alarm system. The audible fire-alarm is to be immediately audible throughout the machinery spaces, the navigating bridge and at manned watch positions as designated by the Naval Authority. Facilities are to be provided in the fire detection system to initiate manually the fire-alarm from positions adjacent to all exits from machinery spaces, the navigating bridge and manned watch positions as designated by the Naval Authority.

2.8.5 Where it is intended that detectors be installed in external locations, in addition to meeting the requirements for an environmental category suitable for open decks, *see* 2.8.8, they are also to be tested for sun irradiation and ultraviolet exposure with satisfactory results.

2.8.6 The alarm system is to be designed with self-monitoring properties. Power or system failures are to initiate an audible alarm distinguishable from the fire-alarm. This alarm may be incorporated in the machinery alarm system as required by 2.3.

2.8.7 When fire detectors are provided with means to adjust their sensitivity, the arrangements are to be such that the set point can be fixed and readily identified.

2.8.8 The fire detector heads are to be of a type which can be tested and reset without the renewal of any component. Facilities are to be provided on the fire-control panel for functional testing and reset of the system.

2.8.9 When it is intended that a particular loop is to be temporarily switched off, this state is to be clearly indicated at the fire detection indicating panels.

2.8.10 When it is intended that a particular detector(s) is to be temporarily switched off locally, this state is to be clearly indicated at the local position. Reactivation of the detector(s) is to be performed automatically after a preset time.

2.8.11 It is to be demonstrated to the Surveyor's satisfaction that detector heads are so located that air currents will not render the system ineffective whether the ship is at sea or in port.

2.8.12 Where an automatic fire detection system is to be fitted in a machinery space, the requirements of 2.8.13 to 2.8.15 are also to be satisfied.

2.8.13 Detector heads are to be located in the machinery spaces so that all potential fire outbreak points are guarded. A combination of detectors is to be provided to ensure that the system will react to all possible fire characteristics.

2.8.14 Fire detection indicating panels are to denote the section in which a detector or manually operated call point has operated. At least one indicating panel is to be located on the navigating bridge unless specified otherwise by the Naval Authority.

2.8.15 A fire detection control unit is to be located in the navigating bridge area, the fire-control station, or in some other position such that a fire in the machinery spaces will not render it inoperable.

2.8.16 Fire detection systems within the accommodation spaces are also to comply with 2.8.17 to 2.8.22.

2.8.17 The fixed fire detection and fire-alarm systems are to be capable of remotely and individually identifying each detector and manually operated call point. At least one indicating unit is to be so located that it is easily accessible to responsible members of the crew. One indicating unit is to be located on the navigating bridge if the control panel is located in the central control station.

2.8.18 Clear information is to be displayed on or adjacent to each indicating unit about the spaces covered and the location of the section and, for passenger ships, each detector and manually operated call point.

2.8.19 The fire detection system is not to be used for any other purpose, except that closing of fire doors and similar functions may be permitted at the control panel.

2.8.20 The fire detection control panel is to be located on the navigating bridge or in the central control station and may form part of that panel specified in 2.8.15.

2.8.21 Detectors and manually operated call points are to be grouped into sections. The activation of any detector or manually operated call point is to initiate a visual and audible fire-alarm signal at the control panel and indicating units. If the signals have not received attention within two minutes an audible alarm is to be automatically sounded throughout the crew accommodation and service spaces, control stations and machinery spaces of Category A. This alarm sounder system need not be an integral part of the detection system.

2.8.22 A section of fire detectors and manually operated call points which covers a control station, a service space or an accommodation space is not to include a machinery space of Category A.

2.10 Programmable electronic systems – General requirements

2.10.6 Emergency ~~stops~~ stop functions are to be hard-wired and independent of any programmable electronic equipment. Alternatively, the system providing emergency stop functions is to comply with the requirements of 2.13.2 and/or 2.13.8.

2.13 Programmable electronic systems – Additional requirements for Mobility category and safety critical systems

2.13.3 Items of programmable electronic equipment used to implement control, alarm ~~and~~ or safety functions are to ~~satisfy the requirements of~~ be Type Approved in accordance with LR's Type Approval System, *Test Specification Number 1 (2002).* Type approval to an alternative and relevant National or International Standard may be submitted for consideration.

2.13.8 Where it is intended that the programmable electronic system implements an emergency stop function or safety critical functions, the software is to satisfy the requirements of LR's *Software Conformity Assessment System – Assessment Module GEN1 (1994)*. Alternative proposals providing an equivalent level of system integrity will be subject to special consideration, e.g., fully independent hard wired back-up system, redundancy with design diversity, etc.

2.14 Programmable electronic systems – Additional requirements for integrated systems

2.14.5 Where the integration involves control functions for essential services or safety functions, including fire safety or crew and embarked personnel or emergency safety functions, the ~~Failure Mode and Effects Analysis (FMEA)~~ Risk Assessment (RA) required by Pt 1, Ch 2,3.3.8 is ~~to~~ additionally to demonstrate that the integrated system will 'fail-safe', *see* 2.4.5 and 2.5.4, and that essential services in operation will not be lost or degraded beyond acceptable performance criteria where specified by these Rules.

■ *Section 6*
Integrated computer control – ICC notation

6.1 General

6.1.2 ~~A Failure Mode and Effects Analysis (FMEA)~~ A Risk Assessment (RA) is to be carried out in accordance with ~~IEC 60812~~ Pt 1, Ch 2,17 and the report and worksheets submitted for consideration, *see also* 2.14.5. The ~~FMEA~~ RA is to demonstrate that control and monitoring functions required by 6.2 will remain available at each operator station in the event of a single fault of the integrated computer control system, including input error, without adverse effect on the service(s).

Volume 2, Part 10, Chapter 1
Electrical Engineering

Effective date 1 January 2014

■ *Section 1*
General requirements

1.2 ~~Plans for design review~~ Documentation required for design review

1.2.1 The ~~plans and particulars~~ documentation in 1.2.2 to 1.2.18 ~~are~~ is to be submitted for design review.

1.2.15 A schedule of batteries fitted for use for emergency and essential services, giving details of:
- type and manufacturer's type designation;
- voltage and ampere-hour rating;
- location;
- equipment and/or system(s) served;
- maintenance/replacement cycle dates;
- date(s) of maintenance and/or replacement; and
- for replacement batteries in storage, the date of manufacture and shelf life~~;~~, with accompanying battery replacement procedure documentation to show compliance with 12.7.

NOTE
The above includes all batteries fitted as part of an uninterruptible power system (UPS) used for any essential or emergency services.

1.3 ~~Plans~~ Documentation required for supporting evidence

1.3.1 The ~~plans and particulars~~ documentation in 1.3.2 to 1.3.5 ~~are~~ is to be submitted as supporting evidence.

1.3.3 Arrangement plans of main and emergency switchboards and section boards, and documentation that demonstrates that creepage and clearance distances are in accordance with 7.5. The form factor of internal separation of low voltage switchgear and control gear assemblies is to be in accordance with IEC 61439-2, *Low-voltage switchgear and control gear assemblies – Part 2: Power switchgear and control gear assemblies*, or an alternative acceptable and relevant national Standard. The form factor is to be stated, and the arrangement plans are to show how the form factor has been achieved.

1.3.4 A ~~Failure Modes and Effects Analysis (FMEA)~~ Risk Assessment (RA), in accordance with Pt 1, Ch 2,17, is required to be submitted, *see* Pt 1, Ch 2,3.3.8. The ~~FMEA~~ RA is to verify the availability of electrical power to essential services in the event of a failure of a system or item of equipment, *see* 5.2.4.

1.7 Design and construction

1.7.4 For areas susceptible to deluge or submersion, cable entries are to prevent water ingress. In general, cable entries are to be in accordance with IEC 60092-101, *Electrical Installations in Ships – Part 101: Definitions and General Requirements.*

■ *Section 5*
Supply and distribution

5.2 Essential services

5.2.4 A ~~Failure Mode and Effects Analysis (FMEA)~~ Risk Based Assessment (RA) is to be carried out in accordance with the requirements of Pt 1, Ch 2,17. The ~~FMEA~~ RA is to verify the availability of electrical power to essential services (*see* 1.6.1) in the event of a failure in the power supply and distribution system. The ~~FMEA~~ RA is to address the different system operating modes and configurations. The ~~FMEA~~ RA should include relevant mechanical failures which may have significant effects on the electrical power and distribution system, i.e., prime mover failures causing loss of electrical power supplies used to provide essential services. An analysis carried out by applying the relevant generic failure modes ~~listed in IEC 60812:1985, *Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)*,~~ to the system and equipment identified in the single line diagram of the electrical system (*see* 1.2.2) would generally be acceptable.

■ *Section 7*
Switchgear and control gear assemblies

7.3 Circuit-breakers

7.3.6 Air circuit-breakers for essential or emergency services and rated at 800 A and above are to have a cumulative count kept of the switching operations of the electrical contacts. This count, along with the manufacturer's details for the circuit-breaker, including the maximum number of switching operations for the electrical contacts, is to be retained on board. These details are to be made available to the Surveyor on request.

7.11 Instruments for alternating current generators

7.11.4 The indicators and displays required by 7.11.1 to 7.11.3 are to be located and arranged such that they may be ~~viewable~~ viewed at a single operating position. Where manual paralleling is provided, it is to be possible to adjust voltage and frequency at this position. Generators are to have controls to adjust their voltage and frequency located at the single operating position. Access to voltage adjustment is to be restricted, such that it will generally only be used by authorised personnel to avoid accidental operation.

■ *Section 9*
Rotating machines

9.1 General requirements

9.1.3 ~~For rotating machines of 100 kW and over intended for essential services, shaft materials are to comply with the *Rules for the Manufacture, Testing and Certification of Materials*.~~ All machines of 100 kW and over, intended for essential services, are to be surveyed by the Surveyor during manufacture and test.

9.1.4 Shaft materials for rotating machines for essential services are to comply with the *Rules for Manufacture, Testing and Certification of Materials* (hereinafter referred to as the Rules for Materials) and are to be manufactured under LR survey for the following applications:

(a) shaft material for dynamic positioning and electric propulsion motors;
(b) shaft material for main engine-driven generators where the shaft is part of the propulsion shafting; and
(c) shaft material for machines with power ratings of 250 kW or greater.

Shaft material for machines with power ratings less than 250 kW is to have a manufacturer's certificate as detailed in Chapter 1 of the Rules for Materials.

Existing paragraphs 9.1.4 *to* 9.1.13 *have been renumbered* 9.1.5 *to* 9.1.14.

■ *Section 10*
Converter equipment

10.3 Uninterruptible power systems

10.3.1 ~~Where uninterruptible power systems (UPS) are required to maintain essential services or provide emergency services, the requirements of this sub-Section apply. This sub-Section is in addition to the requirements of 10.1 to 10.2 and Section 12, as applicable.~~ The requirements of this sub-Section apply to all uninterruptible power systems (UPS) intended to maintain essential services or provide emergency services. This sub-Section is in addition to the requirements of 10.1 to 10.2 and Section 12, as applicable.

10.3.12 Tests at the manufacturer's works or after installation on board are to include such tests necessary to demonstrate to the Surveyor's satisfaction the suitability of ~~a~~ the UPS unit for its intended duty and location. ~~This is expected to include as~~ As a minimum, the following tests are required:

- a temperature rise test ~~and battery capacity test on one of each size and type of UPS~~;
- ~~the high voltage test of 21.1;~~
- battery capacity test;
- a ventilation rate test of both the equipment housing and the space into which it is to be located, *see also* 12.5; and
- functional testing, including operation of alarms.

Details of tests are to be submitted for consideration when required, *see also* 1.4.2.

Section 11
Electric cables, optical fibre cables and busbar trunking systems (busways)

11.1 General

11.1.1 The requirements of 11.1 to ~~11.15~~ 11.16 apply to all electric and optical fibre cables for fixed wiring unless otherwise exempted. The requirements of 11.17 apply to busbar trunking systems (busways) where they are used in place of electric cables.

11.1.3 Details of optical fibre cables for fixed installation are to be submitted to assess compliance with applicable international or National Standards. These are to include:
- Flame retardancy;
- Fire resistance (if applicable);
- Smoke density;
- Halogen content;
- Mechanical properties;
- Suitability for use in the marine environment.

Existing paragraphs 11.1.3 *and* 11.1.4 *have been renumbered* 11.1.4 *and* 11.1.5.

(*Part only shown*)

Table 1.11.1 Electric cables

Application	IEC Standard	Title
~~Instrumentation, control and communication circuits up to 60 V~~	~~60092-375~~	~~Shipboard telecommunication cables and radio-frequency cables – General instrumentation, control and communication cables~~
Control and instrumentation circuits up to 250 V	60092–376	~~Shipboard multicore cables~~ Cables for control and instrumentation circuits
Mineral insulated	~~600702~~ 60702	Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V

~~*11.1.5*~~ *11.1.6* Electric and optical fibre cables for non-fixed ~~wiring~~ applications are to comply with ~~an acceptable and relevant standard~~ a relevant National or International Standard.

~~*11.1.6*~~ *11.1.7* For the purpose of this Section, pipes, conduits, trunking or any other system for the additional mechanical protection of cables are ~~hereafter~~ hereinafter referred to under the generic name 'protective casings'.

11.1.8 Electrical cables for telecommunications and data transfer are, whenever practicable, to be selected in accordance with the recommendations of IEC TR 60092-370, *Guidance on the selection of cables for telecommunication and data transfer including radio-frequency cables*.

11.5 Construction

11.5.1 Electric and optical fibre cables are to be at least of a flame-retardant, low smoke, halogen free type. Compliance with IEC 60332-1-2: *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1kW pre-mixed flame*, IEC 61034: *Measurements of smoke density of electric cables burning under defined conditions*, IEC 60754: *Tests on gases evolved during combustion of materials from cables* will be acceptable. Where cables are installed in bunches, the requirements of 11.8.10 are to be satisfied. Alternative proposals for equipment cabling that demonstrate satisfactory smoke and toxicity performance under fire conditions for identified areas of a ship may be submitted for consideration where requested by the Naval Authority.

(*Part only shown*)

11.5.3 Where electric or optical fibre cables are required to be of a 'fire resistant type', they are in addition to be easily distinguishable and comply with the performance requirements of the appropriate part of IEC 60331: *Tests for electric cables under fire conditions – Circuit integrity, when tested with a minimum flame application time of 90 minutes*, as follows:

11.5.4 Where electric or optical fibre cables are installed in locations exposed to the weather, in damp and in wet situations, in machinery compartments, refrigerated spaces or exposed to harmful vapours including oil vapour, they are to have the conductor insulating materials or optical fibres enclosed in an impervious sheath of material appropriate to the expected ambient conditions. ~~Where cables are required to remain operational when immersed in water, oil or other substances for prolonged periods, the cable sheathing is to be demonstrably suitable for this environment. Evidence of immersion testing is to be submitted for consideration on request.~~

11.5.5 Where electric or optical fibre cables are installed in locations which are totally submerged for extended periods of time, they are to have the conductor insulating materials or fibres enclosed in an impervious sheath of material appropriate to the expected submerged conditions and duration.

~~*11.5.5*~~ *11.5.6* Where it is required that the construction of electric~~al~~ or optical fibre cables includes metallic sheaths, armouring or braids, they are to be provided with an overall impervious sheath or other means to protect the metallic elements against corrosion, *see also* 11.8.7 and 11.8.8.

Existing paragraphs 11.5.6 *to* 11.5.9 *have been renumbered* 11.5.7 *to* 11.5.10.

11.6 Conductor size

Table 1.11.3 Electric cable current ratings, normal operation, based on ambient 45°C (*Part only shown*)

Nominal cross-section (mm^2)	Continuous r.m.s. current rating, in amperes								
	Thermoplastic (70°C)			Elastomeric (90°C)			Elastomeric or thermosetting, based on silicone rubber (95°C)		
	Single core	2 core	3 or 4 core	Single core	2 core	3 or 4 core	Single core	2 core	3 or 4 core
2,5	21	18	15	~~40~~ 30	26	21	32	27	22
3,5	26	22	18	37	32	26	39	33	28
4	29	25	20	~~51~~ 40	34	28	43	37	30

11.8 Installation of electric cables

11.8.1 Electric and optical fibre cable runs are to be, as far as practicable, fixed in straight lines and in accessible positions.

11.8.2 Bends in fixed electric and optical fibre cable runs are to be in accordance with the cable manufacturer's recommendations. The minimum internal radius of bend for the installation of fixed electric cables is to be chosen according to the construction and size of the cable and is not to be less than the values given in Table 1.11.6.

11.8.3 The installation of electric and optical fibre cables across expansion joints in any structure is to be avoided. Where this is not practicable, a loop of cable of length sufficient to accommodate the expansion of the joint is to be provided. ~~The~~ For electric cables, the internal radius of the loop is to be at least 12 times the external diameter of the cable. For optical fibre cables, the internal radius of the loop is to meet the manufacturers' minimum recommendations.

11.8.4 Electric and optical fibre cables for essential and emergency services are to be arranged, so far as is practicable, to avoid galleys, machinery spaces and other enclosed spaces and high fire risk areas except as is necessary for the service being supplied. Such cables are also, so far as reasonably practicable, to be routed clear of bulkheads to preclude ~~their~~ them being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

11.8.6 Electric and optical fibre cables having a protective covering which may damage the covering of other cables are not to be bunched with those other cables.

11.8.9 Electric and optical fibre cables are to be, as far as practicable, installed remote from sources of heat. Where installation of cables near sources of heat cannot be avoided and where there is consequently a risk of damage to the cables by heat, suitable shields, insulation or other precautions are to be installed between the cables and the heat source. The free air circulation around the cables is not to be impaired.

11.8.10 Where electric and optical fibre cables are installed in bunches, provision is to be made to limit the propagation of fire. This requirement is considered satisfied when cables of the bunch have been tested in accordance with the requirements of IEC 60332: *Tests on electric and optical fibre cables under fire conditions, Part 3-22, Test for vertical flame spread of vertically mounted bunched wires or cables – Category A*, provided that, in addition, there is no shedding of flaming droplets of sheath or insulation material and that they are installed in the same configuration(s) as used in the test(s). If the cables are not so installed, information is to be submitted to demonstrate satisfactorily that suitable measures are taken to ensure that an equivalent limit of fire propagation will be achieved for the configuration(s) used. Particular attention is to be given to cables in vertical runs in trunks and other restricted spaces. In addition, cables that comply with the requirements of IEC 60332-3-22 are also required to meet the requirements of IEC 60332-1-2.

11.8.11 Electric and optical fibre cables are not to be coated or painted with materials which may adversely affect their sheath or their fire performance.

11.8.12 Where electric and optical fibre cables are installed in refrigerated spaces, they are not to be covered with thermal insulation but may be placed directly on the face of the refrigeration chamber, provided that precautions are taken to prevent the electric cables being used as casual means of suspension.

11.8.13 All metal coverings of electric and optical fibre cables are to be earthed in accordance with 1.12.

11.8.17 Electric and optical fibre cables are to be, so far as reasonably practicable, installed remote from sources of mechanical damage. Where necessary the cables are to be protected in accordance with the requirements of 11.9.

11.8.18 Electric and optical fibre cables, with the exception of those for portable appliances and those installed in protective casings, are to be fixed securely in accordance with the requirements of 11.10.

11.8.19 Electric and optical fibre cables serving any essential services and any glands through which they pass must be able to withstand flooding for a period of 18 hours, based on the water pressure that may occur at the location.

~~*11.8.19*~~ *11.8.20* Where electric and optical fibre cables penetrate bulkheads and decks, the requirements of 11.11 are to be complied with.

~~*11.8.20*~~ *11.8.21* Where electric and optical fibre cables are installed in protective casings, the requirements of 11.12 are to be complied with.

Existing paragraph 11.8.21 *has been renumbered* 11.8.22.

11.11 Penetration of bulkheads and decks by cables

11.11.1 Where electric or optical fibre cables pass through watertight, fire insulated or gastight bulkheads or decks separating hazardous zones or spaces from non-hazardous zones or spaces, the arrangements are to be such as to ensure the integrity of the bulkhead or deck is not impaired. The arrangements chosen are to ensure that the cables are not adversely affected.

11.11.3 Electric and optical fibre cables passing through decks are to be protected by deck tubes or ducts.

11.12 Installation of electric and optical fibre cables in protective casings

11.12.1 Protective casings are to be mechanically continuous across joints and effectively supported and secured to prevent damage to the electric or optical fibre cables.

11.12.7 Protective casings containing high voltage electric cables are not to contain other electric or optical fibre cables and are to be clearly identified, defining their function and voltage.

11.16 Joints and branch circuits in cable systems

11.16.1 If a joint is necessary it is to be carried out so that all conductors or fibres are adequately secured, insulated and protected from atmospheric action. The flame retardant properties or fire resisting properties of the cable are to be retained, the continuity of metallic sheath, braid or armour is to be maintained and the current-carrying capacity or transmission of data through the cable is not to be impaired.

11.16.3 Tappings and splices of optical fibre cables are to be made in accordance with the manufacturers' recommendations and are to be provided with appropriate fittings. In addition they are to be located within suitably designed enclosures to ensure that the protection of the optical fibres is maintained.

Existing paragraph 11.16.3 *has been renumbered* 11.16.4.

■ *Section 13*
Equipment – Heating, lighting and accessories

13.4 Fluorescent lighting

13.4.1 Fluorescent lamps and lampholders are to be in accordance with Table 1.13.1.

Table 1.13.1 Lamps and lampholders

Designation	Maximum lamp rating		Maximum lampholder current, A
	Voltage, V	Power, W	
Screw cap lamps			
E40	250	3000	16
E27	250	200	4
E14	250	15	2
E10	24	—	2
Bayonet cap lamps			
B22	250	200	4
B15d	250	15	2
B15s	55	15	2
Tubular fluorescent lamps			
G13	250	~~80~~ 115	—
G5	250	~~13~~ 80	—

NOTE
Other lamp types are to be in accordance with IEC 60092-306, *Electrical installations in ships - Part 306: Equipment – Luminaires and lighting accessories.*

■ *Section 14*
Electrical equipment for ~~the~~ use in explosive gas atmospheres or in the presence of combustible dusts

14.10 Requirements for oil supply ships intended for the carriage in bulk of oil cargoes having a flash point not exceeding 60°C (closed-cup test)

14.10.3 Further to the requirements of paragraph 14.5.6, open deck, or semi-enclosed spaces on open deck, within 3 m of the ventilation outlets of tanks defined in 14.5.4(a), which permit the flow of small volumes of vapour or gas mixtures caused by thermal variation are to be regarded as hazardous **zone 1**.

14.10.4 Further to the requirements of paragraph 14.5.7, open deck extending 2 m beyond those defined by 14.5.6(e) are to be regarded as hazardous **zone 2**.

■ *Section 16*
Electric propulsion

16.2 System design and arrangement

16.2.2 For vessels where a propulsion device driven by electric motors is proposed as the sole means of propulsion, at least two effective, independent electric propulsion motors are to be provided and the system is to be designed in accordance with Pt 1, Ch 5. ~~The risk management process~~ A Risk Assessment, in accordance with Pt 1, Ch 2,17, is to identify components where a failure could cause loss of propulsion power or other essential services and the proposed arrangements for preventing and mitigating the effects of such a failure.

16.4 Propulsion control

16.4.7 Each control station is to be provided with an emergency ~~stops~~ stop function for the propulsion ~~motors~~ motor(s). The emergency stop function is to be independent of the normal control system.

■ *Section 17*
Fire safety systems

17.1 Fire detection and alarm systems

~~*17.1.1* Fire detection and alarm systems are to be in~~ accordance with Chapter 9 of the *Fire Safety Systems Code (FSS Code)* and 17.1.2 to 17.1.15.

17.1.2 Fire detection and alarm systems are to be provided with at least two power supplies. One supply is to be connected to the main source of electrical power and another supply is to be connected to the emergency source of electrical power required by 3.2, or an accumulator battery capable of supplying power for the same period of time as the emergency source of electrical power. All power supply feeders for fire detection and alarm systems are to be in accordance with 11.6.4.

17.1.3 Automatic changeover facilities in accordance with 5.3.4 are to be located in, or adjacent to, the main fire control panel. Power supply changeover is to be achieved without adverse affect. Failure of any power supply is to operate an audible and visual alarm. *See also* 1.15 and 1.17.

17.1.4 Where an accumulator battery provides a power supply, on restoration of the main source of electrical power, the rating of the charge unit is to be sufficient to recharge the battery while maintaining the output supply to the fire detection and alarm system.

17.1.5 Power supplies from the main and emergency switchboards are to be supplied by separate feeders that are reserved solely for this purpose. Where the emergency feeder for the electrical equipment used in the operation of the fixed fire detection and fire alarm system is supplied from the emergency switchboard, it is to be run from this switchboard to the automatic changeover switch without passing through any other switchboard.

~~*17.1.6* For machinery spaces the requirements of Pt 9,~~ Ch 1,2.8 are applicable.

17.1.7 The fire detection system within the accommodation spaces is, in addition to the requirements of Pt 9, Ch 1,2.8.4, 2.8.6, 2.8.8 and 2.8.10 to 2.8.14, to comply with 17.1.8 to 17 .1.16.

17.1.8 The fire detection control panel is to be located on the navigating bridge or in the central control station and may form part of that panel specified in Pt 9, Ch 1,2.8.2.

17.1.9 Detectors and manually operated call points are to be grouped into sections. The activation of any detector or manually operated call point is to initiate a visual indication and audible fire alarm signal at the control panel and indicating units. If the signals have not received attention within two minutes an audible signal is to be automatically sounded throughout the crew accommodation and service spaces, control stations and machinery spaces of Category A. This alarm sounder system need not be an integral part of the detection system.

17.1.10 The fixed fire detection and fire alarm system are to be capable of remotely and individually identifying each detector and manually operated call point. At least one indicating unit is to be so located that it is easily accessible to responsible members of the crew. One indicating unit is to be located on the navigating bridge if the control panel is located in the central control station.

17.1.11 Clear information is to be displayed on or adjacent to each indicating unit about the spaces covered and the location of the section and each detector and manually operated call point.

17.1.12 A section of fire detectors which covers a control station, a service space or an accommodation space is not to include a machinery space of Category A.

17.1.13 The fire detection system is not to be used for any other purpose, except that closing of fire doors and similar functions may be permitted at the control panel.

17.1.14 A loop circuit of an addressable fire detection system, capable of remotely identifying from either end of the loop each detector served by the circuit, may serve spaces on both sides of the ship and on several decks, but is not to be situated in more than one main vertical or horizontal fire zone, nor is a loop circuit which covers a control station or an accommodation space to include a machinery space of Category A.

17.1.15 A loop circuit of an addressable fire detection system may comprise one or more sections of detectors. Where the loop comprises more than one section, the sections are to be separated by devices which will ensure that if a short-circuit occurs anywhere in the loop, only the affected section of detectors will be isolated from the control panel. No section of detectors is, in general, to include more than ~~50 detectors.~~

~~*17.1.16* A section of detectors of an addressable fire detection system is neither to serve spaces on both sides of the ship nor on more than one deck, except that:~~

~~(a) a section of detectors may serve spaces on more than one deck if those spaces are located in either the fore and aft end of the ship or they constitute common spaces occupying several decks, i.e. personnel spaces, enclosed stairways, etc.~~

~~(b) in ships of less than 20 m in breadth, a section of detectors may serve spaces on both sides of the ship.~~

~~*17.1.17* The wiring for each section of detectors in an addressable fire detector system is to be separated as widely as practicable from that of all other sections on the same loop.~~

17.1.1 Fire detection and alarm systems are to comply with Chapter 9 of the *Fire Safety Systems Code (FSS Code)* and 17.1.2 to 17.1.10.

17.1.2 Fire detection and alarm systems are to be provided with at least two power supplies. One supply is to be connected to the main source of electrical power and another supply is to be connected to the emergency source of electrical power required by 3.2, or an accumulator battery capable of supplying power for the same period of time as the emergency source of electrical power. All power supply feeders for fire detection and alarm systems are to be in accordance with 11.6.4.

17.1.3 Automatic changeover facilities in accordance with 5.3.4 are to be located in, or adjacent to, the main fire-control panel. Power supply changeover is to be achieved without adverse effect. Failure of any power supply is to operate an audible and visual alarm. *See also* 1.15 and 1.17.

17.1.4 Where an accumulator battery provides a power supply, on restoration of the main source of electrical power, the rating of the charge unit is to be sufficient to recharge the battery while maintaining the output supply to the fire detection and alarm system.

17.1.5 Power supplies from the main and emergency switchboards are to be supplied by separate feeders that are reserved solely for this purpose. Where the emergency feeder for the electrical equipment used in the operation of the fixed fire detection and alarm system is supplied from the emergency switchboard, it is to be run from this switchboard to the automatic changeover switch without passing through any other switchboard.

17.1.6 A loop circuit of an addressable fire detection system, capable of remotely identifying from either end of the loop each detector and manually operated call point served by the circuit, may serve spaces on both sides of the ship and on several decks, but is not to be situated in more than one main vertical or horizontal fire zone, nor is a loop circuit which covers an accommodation space, service space and/or control station to include a machinery space of Category A.

17.1.7 A loop circuit of an addressable fire detection system may comprise one or more sections. Where the loop comprises more than one section, the sections are to be separated by devices which will ensure that, if a short-circuit occurs anywhere in the loop, only the affected section will be isolated from the control panel. No section of detectors and manually operated call points is, in general, to include more than 50 detectors.

17.1.8 A section of detectors of an addressable fire detection system is neither to serve spaces on both sides of the ship nor on more than one deck, except that:

(a) a section of detectors may serve spaces on more than one deck if those spaces are located in either the fore and aft end of the ship or they constitute common spaces occupying several decks, i.e., personnel spaces, enclosed stairways, etc.

(b) in ships of less than 20 m in breadth, a section of detectors may serve spaces on both sides of the ship.

17.1.9 A section of fire detectors and manually operated call points of an addressable system is not to be situated in more than one main vertical zone.

17.1.10 The wiring for each section of detectors and manually operated call points in an addressable fire detector system is to be separated as widely as practicable from that of all other sections on the same loop.

■ *Section 18*
Crew and embarked personnel emergency safety systems

18.3 Crew and embarked personnel address system

18.3.3 The crew and embarked personnel address system is to have multiple amplifiers having their power supplies so arranged that a single fault, fire or casualty will not cause the loss of the facility to broadcast emergency announcements in crew and embarked personnel rooms, alleyways, stairways and control stations, albeit at a reduced capacity.

18.3.4 The crew and embarked personnel address distribution system is to be so arranged that a fire or casualty in any one main vertical zone, other than the zone in which the crew and embarked personnel address control station is located, will not interfere with the ~~distribution~~ facility to broadcast emergency announcements in any other such zone, *see also* 1.17.

18.3.5 There are to be at least two cable routes in each fire zone sufficiently separated throughout their length to crew and embarked personnel rooms, alleyways, stairways, and control stations so arranged that any single electrical fault, localised fire or casualty will not cause the loss of the facility to broadcast emergency announcements in any crew and embarked personnel rooms, alleyways, stairways, and control stations, albeit at a reduced capacity.

Volume 2, Part 12, Chapter 1
Emissions Abatement Plant for Combustion Machinery

Effective date 1 January 2014

■ *Section 1* General

1.1 Scope

1.1.1 The requirements of this Chapter apply to equipment fitted to combustion machinery in order to reduce emissions produced by the combustion of fuel. Such equipment is hereinafter referred to as emissions abatement plant.

These requirements are intended to ensure that the emissions abatement plant is safe to operate and maintain and, additionally, where the combustion machinery provides power for essential services, that failure of the emissions abatement plant does not result in an unacceptable loss or degradation of those essential services.

These requirements do not provide for the reliability or redundancy necessary to ensure continued operation of the emissions abatement plant, and thereby compliance with relevant emissions requirements, following failure of any equipment associated with the emissions abatement plant.

1.1.2 This Chapter is to be read in conjunction with the requirements for Machinery and Engineering Systems in Part 1.

■ *Section 2* Functional requirements

2.1 General

2.1.1 The emissions abatement plant is to be capable of operating at the maximum output power of the combustion machinery to which it is connected. Where the machinery installation is configured such that it is not intended to operate all the combustion machinery connected to the emissions abatement plant simultaneously in normal operating conditions, this will be subject to special consideration and supported by the submission required by 3.1.2. For engines, the maximum power is as stated on the Engine International Air Pollution Prevention Certificate (EIAPPC) or an equivalent certificated engine rating for vessels which are not subject to MARPOL Annex VI.

2.1.2 Operation and maintenance of the emissions abatement plant is not to present a hazard to the ship's occupants or to the environment and should not impair the functioning of Mobility category or Ship Type category systems.

2.1.3 Failure of the emissions abatement plant is not to present a hazard to the ship's occupants and should not impair the functioning of Mobility category or Ship Type category systems.

2.1.4 Where the emissions abatement plant is connected to combustion machinery providing power for essential services, failure, or the inability to operate the emissions abatement plant, is not to prevent the combustion machinery from delivering sufficient power to those essential services to ensure the safe operation of the ship.

2.1.5 Any discharges overboard from the emissions abatement plant are to be in accordance with the requirements of National and International regulations, as applicable.

■ *Section 3* Information to be submitted

3.1 General

3.1.1 The information required by this Section and the information required by Vol 1, Pt 3, Ch 1,4 and Chapter IV of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk* (hereinafter referred to as the Rules for Ships for Liquid Chemicals), as applicable.

3.1.2 A description of the emissions abatement plant and the abatement technique(s) used. This is to include details of the proposed combustion machinery operating configurations using a common emissions abatement system for multiple exhaust gas inlet streams and any limitations on the operation of combustion machinery connected to the emissions abatement system.

3.1.3 Where emissions abatement plant makes use of more than one abatement technique, e.g., separate means for reducing NO_x and SO_x, details demonstrating their compatibility with the combustion machinery and with each other.

3.1.4 Diagram(s) showing the process flows.

3.1.5 Details of the maximum and minimum ambient and sea-water temperatures within which the emissions abatement plant is to operate, and maximum and minimum ambient air temperature and humidity where applicable.

3.1.6 **Risk Based Analysis (RBA)**. The RBA required by Pt 1, Ch 2,3.3.8 is to include consideration of the emissions abatement plant. It shall specifically detail the hazards associated with operation, maintenance and reasonably foreseeable failure of the emissions abatement plant and the means by which they are mitigated, demonstrating that the operation of essential services shall not be impaired by such scenarios. *See also* Pt 1, Ch 2,17.

3.1.7 Details of any fuel treatments, fuel additives or fuel emulsification used as a primary means of emissions abatement from combustion machinery, together with a manufacturer's letter confirming the suitability of combustion machinery to operate with such treatments and additives. Details are to include evidence that materials, fuel filtration and arrangements for the control of viscosity and temperature have been suitably modified, along with evidence of the suitability of fuel pumps and fuel valves for the treated fuel, with particular attention to viscosity, lubricity and stability, as applicable.

3.2 Materials

3.2.1 Details of the materials proposed for all types of construction.

3.3 Chemical substances

3.3.1 Details of the flammability, toxicity, corrosivity and reactivity of any chemicals used, together with details of any exothermic and hazardous reactions, particularly with regard to sea-water.

3.3.2 General arrangement of spaces where toxic or flammable liquids, gases, dusts or vapours are stored or may accumulate, indicating the hatches and other access openings.

3.3.3 Details of arrangements for loading, storage, transfer and disposal of chemicals, by-products or waste products.

3.3.4 General arrangement showing spaces maintained at an over-pressure to prevent the ingress of gases, dusts or vapours.

3.3.5 Details and arrangements of blowdown and bleed-off systems, where applicable, including quantities of chemicals, substances and effluents and the capacity and working pressure of tanks and receivers installed for the reception of such substances and effluents.

3.3.6 Arrangements for purging, gas freeing, inerting or otherwise rendering safe of the emissions abatement plant and storage facilities for chemicals, effluent and by-products associated with the plant.

3.3.7 The flow and return flow of chemicals, substances, effluent or by-products, including:

(a) Substance supply and product discharge, with details of the arrangements showing the location of shut-off valves and of the control and indicating stations.

(b) The process plant parameters and analysis of conditions under which emergency shut-down will be initiated.

(c) Measures to eliminate risk of process fluid reverse flows which could present a risk to propulsion engines, auxiliary engines and essential services.

(d) The proposed emergency procedures for controlled shut-down of the plant, i.e., depressurising, isolating and the arrangements for the continued operation of the essential services necessary to allow for such controlled shut-down under the emergency conditions identified in 3.3.7(b), as applicable.

3.3.8 Proposals for the decontamination of the emissions abatement plant compartments for installations using chemicals, substances and/or producing effluent or by-products or where there is a possibility of generating hazardous substances during the operation of plant. These proposals are to include both normal operating requirements for decontamination (such as for carrying out maintenance) and post-incident decontamination.

3.3.9 Arrangement for the detection of liquids, gases and vapours where such substances could present a fire, explosion or health hazard.

3.4 Mechanical equipment

3.4.1 Details of mechanical equipment associated with the emissions abatement plant to be installed.

3.4.2 Details of any safety and pressure-relief devices and their discharge arrangements.

3.4.3 Plans showing the materials of construction, working pressures and temperatures, maximum and minimum exhaust gas flows, fuel quality parameters, maximum and minimum flow rates of any water, fluids, chemicals or substances required by the process, maximum effluent or by-product discharge rate resulting from the process.

3.4.4 Details of the arrangements for protecting the emissions abatement plant, its tanks and vessels against temperature, over-pressure and vacuum. Details are to include consideration of storage temperature requirements and, where applicable, tanks are to be maintained within the temperature limits of the chemicals and substances they contain so as to avoid risks of boiling, stress corrosion, freezing and other temperature-sensitive processes.

3.4.5 Details of the by-pass arrangements or, where considered unnecessary, evidence demonstrating that the emissions abatement plant is capable of continued operation with the expected gas flows. Evidence is to include conditions where the emissions abatement plant is in a shut-down condition, both as a result of emergency conditions and when shut down for normal operational reasons. This is to be supported by detailed proposals demonstrating material suitability and is to ensure that, where there is a risk of blockage, this can be monitored so as to ensure that remedial action can be taken before blockage presents a risk to both combustion machinery and emissions abatement plant operations.

3.5 Pressure vessels

3.5.1 Plans of any pressure vessels, including details of their supports. Diagrammatic plans for systems associated with emissions abatement process equipment as required by Part 8, as applicable.

3.5.2 Details of the safety and pressure-relief devices and their discharge arrangements.

3.5.3 Stress calculations taking into account the ship linear and angular accelerations, roll and pitch amplitudes, ship flexure and wind loads, appropriate to any condition which may normally arise at sea.

3.6 Pumping and piping

3.6.1 Plans of the emissions abatement plant piping systems, showing the materials of construction, scantlings, support and expansion arrangements, together with the calculations.

3.6.2 Diagrammatic plans for systems associated with emissions abatement process equipment, as required by Pt 7, Ch 1, Ch 2 and Ch 3 and by the Rules for Ships for Liquid Chemicals, as applicable.

3.6.3 Plans showing the arrangement and dimensions of main exhaust pipes, with details of flanges, bolts and weld attachments and particulars of the materials of the pipes, flanges, bolts and welding consumables.

3.6.4 Details of the safety and pressure-relief devices and their discharge arrangements.

3.6.5 Details of air and sounding pipes to tanks containing chemicals, substances and effluent.

3.6.6 The arrangements for the storage on board the ship, and the disposal, of bilge and effluent from the emissions abatement plant spaces, giving particular consideration to the risk of flooding as a result of emissions abatement plant failure. Recognition is to be given to the requirements of the appropriate National Authority.

3.7 Electrical and control equipment

3.7.1 General arrangement plan of the process plant, showing the location of the major items of electrical and control equipment.

3.7.2 The plans and particulars required by Vol 2, Pt 9, Ch 1,1.2 and Vol 2, Pt 10, Ch 1,1.3.

■ *Section 4* Materials

4.1 General

4.1.1 The materials used in the construction of the emissions abatement plant and any associated chemical and effluent storage tanks are to be manufactured and tested in accordance with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials* and/or the Rules for Ships for Liquid Chemicals.

■ *Section 5* Hull construction

5.1 General

5.1.1 The hull structure is to comply with the relevant requirements of Vol 1, Parts 3, 4, 5 and 6, except where stated otherwise in this Section.

5.1.2 All substance and effluent tank structures and their location relative to the ship's hull are to comply with Chapters 2 and 4 of the Rules for Ships for Liquid Chemicals, as applicable.

5.1.3 Where necessary, the probable temperature variations during operations and the thermal stress considerations are to be stated. Where it is necessary either to heat or cool chemical storage tanks, the arrangements are to meet the requirements of Chapter 7 of the Rules for Ships for Liquid Chemicals.

5.1.4 Where independent tanks are used for chemical substances, these are to be bunded to contain spillage. The bund is to comply with the following:

(a) the bund is dimensioned so as to contain 1,5 times the maximum contents of the tank, ensuring that consideration has also been given to the angle of inclination requirements for main and auxiliary machinery in Table 2.4.2 in Pt 1, Ch 2,4; or

(b) there is a drain arrangement meeting the requirements of 5.1.6; or

(c) the tank is located in a dedicated compartment containing no equipment other than that required by the tank with permanent access and floor plates positioned above the liquid level if the tank were to discharge its full contents into the compartment. Any valves, equipment and emergency stop functions are to be operable from outside this compartment and meet the requirements of 5.2.

Tanks and spill containment arrangements are to be fitted with alarms and safeguards, in accordance with Table 1.9.1.

5.1.5 Proposals are to be made for the dimensioning of containment arrangements, relative to the potential leakage which may require containment. Where it is not practicable to contain fully the potential leakage and where this leakage can pose a hazard to personnel, proposals are to be submitted, demonstrating that leakage will be transferred to a suitable retention tank, and the means of transfer shall be capable of operating in a dead ship condition and shall be fitted with a flow detection alarm, in accordance with Table 1.9.1.

5.1.6 Tanks are to be arranged such that any residues and slops can be pumped out, drained or otherwise removed from the tank without exposing personnel to these residues and slops.

5.1.7 Chemical tanks are not to be located in the same space as essential machinery and equipment.

5.1.8 Arrangements for venting and gas-freeing chemical tanks required by emissions abatement plant are to meet the requirements of Chapter 8 of the Rules for Ships for Liquid Chemicals.

5.2 Location service and control spaces

5.2.1 Where flammable or toxic chemicals, gases or vapours are present, as identified in 3.3.1 and 3.3.2, service and control stations essential to the operation of the plant are to meet the requirements of 9.1.4, and should, wherever possible, be located so that access thereto is from a defined safe space. If such a location is not possible, the station is to be specially ventilated.

5.2.2 Arrangements are to be made in spaces occupied by emissions abatement plant so that substances which are flammable, corrosive, toxic or are likely to present a hazard due to reaction when mixed are kept separate unless they are fully contained within a part of the emissions abatement system which has been designed for the safe mixing of such substances.

5.3 Integrity of water and gastightness between compartments

5.3.1 Where integrity of water or gastightness is required between compartments containing the plant, it is to be maintained in way of pipe tunnels or duct keels where these traverse such compartments.

5.3.2 Installations and the spaces in which they are installed are to be, in all cases, compliant with applicable National and International requirements for prevention, detection and extinction of fire.

5.4 Cofferdams

5.4.1 Cofferdams are to be sited, as required by the Rules for Ships for Liquid Chemicals, as applicable, segregating any spaces in which chemicals, substances or effluents are stored or retained in bulk.

5.5 Plant support structure

5.5.1 Decks and other structures supporting the plant are, in general, to comply with the requirements of Volume 1. Such structures can, however, be considered on the basis of an agreed uniformly distributed loading in association with local loads at plant support points, provided that adequate transverse strength of the ship is maintained.

5.5.2 Where the nature and dispositions of heavy plant items are such that forces on the ship and support structure due to ship motions are significant (whether underway with or without working fluids, or moored with working fluids), calculations of the loading and the structural response are to be submitted.

5.6 Loading due to wave-induced motions

5.6.1 In cases where the mass distribution of large columnar equipment items is such that the centre of action of the dynamic force differs significantly from the centre of gravity of the item, due account of this is to be taken in the calculation of the forces and moments at the support positions.

5.7 Integrity of weather deck

5.7.1 The integrity of the weather deck is to be maintained. Where items of plant penetrate the weather deck and are intended to constitute the structural barrier to prevent the ingress of water to spaces below the freeboard deck, their structural strength is to be equivalent to the Rule requirements for this purpose. Otherwise, such items are to be enclosed in superstructures or deckhouses fully complying with the Rules.

■ *Section 6* Mechanical equipment

6.1 General

6.1.1 Emissions abatement plant associated with diesel engines and gas and steam turbines is to comply with the requirements of Pt 2, Ch 1, Ch 2 and Ch 3 respectively, as applicable.

6.1.2 The mounting arrangements for the equipment are to be capable of withstanding the forces and moments stated in 5.5 and 5.6.

6.1.3 The design is to take account of the risk of fire or explosion hazards which may arise from deposition of chemicals, unburnt fuel, particulates or any by-products of chemical reactions which may arise during normal operation.

6.1.4 The emissions abatement plant is to be capable of being started without risk of failure due to thermal shock.

6.1.5 Safety or pressure-relief devices are to discharge to places which will not present a hazard to the ship's occupants or to any machinery.

6.1.6 Where bursting discs or rupture panels are used as safety and pressure-relief devices, these are to be dimensioned and designed in accordance with a recognised National or International Standard.

6.1.7 Where it can be expected that there will be deposition of materials, caking and waste, arrangements are to be provided for the safe cleaning of such systems.

6.1.8 Where there is a possibility of operating conditions in the system falling below the dew point temperature of any gases or vapours present in the system, suitable drains are to be provided to permit the discharge of any condensate formed.

6.2 By-pass or equivalent arrangements

6.2.1 The emissions abatement plant is to be provided with a by-pass capable of transmitting the minimum and maximum exhaust gas flows from the combustion machinery to which it is connected. Where a by-pass is considered unnecessary, the emissions abatement plant is to be capable of safely transmitting the minimum and maximum exhaust gas flows with the emissions abatement plant out of operation, such that the combustion machinery to which it is connected can continue to operate.

6.2.2 Where a by-pass is fitted, there is to be a flow path for exhaust gas at all times.

6.2.3 A means of measuring differential pressure across the emissions abatement plant is to be provided.

6.3 Shared emissions abatement plant

6.3.1 Where the emissions abatement plant is connected to more than one item of combustion machinery, valves or equivalent means of isolating the exhaust systems of individual items of combustion machinery from common manifolds are to be provided to prevent reverse flow of exhaust gas into the exhaust manifolds of combustion machinery which has been shut down.

6.3.2 Where isolating valves are fitted, a means to verify the effectiveness of the isolation is to be provided.

6.4 Maintenance of back-pressure

6.4.1 The exhaust back-pressure, after installation of the emissions abatement plant, is to remain within the allowable limits stated by the combustion machinery manufacturers under all expected operating conditions, unless it is intended to operate the system at a negative pressure by means of an induced draught fan.

6.4.2 Where an induced draught fan is fitted to maintain the required exhaust back-pressure, failure of the fan is not to prevent the combustion machinery from operating.

6.4.3 Where the emissions abatement plant is fed from multiple exhaust gas inlet streams, the back-pressure is to be maintained within the allowable limits provided by the combustion machinery manufacturers for all operating configurations.

6.5 Protection of combustion machinery

6.5.1 Measures are to be implemented to ensure that water from the emissions abatement plant cannot flow back into the combustion machinery.

6.5.2 Means are to be provided for protecting critical combustion machinery components from foreign object damage resulting from failure of, or damage to, the emissions abatement plant. Where such damage is considered unlikely, evidence is to be submitted accordingly.

6.5.3 Where chemicals or substances are injected into the exhaust gas stream before turbo-charger(s) or emissions abatement plant are fitted, this is not to present a risk of damage, chemical attack or performance degradation to the machinery with which they are associated.

6.5.4 Where fuel treatments, additives or emulsification are used as a primary means of abating exhaust emissions, machinery is to be compatible with such additives, treatments and emulsified fuel.

6.5.5 Where exhaust gas is recirculated as a means of emission abatement, the recirculated exhaust gas is not to cause fouling and corrosion of critical machinery components and scavenge air temperature is to be maintained at a level which does not adversely affect engine performance.

6.5.6 Where a wet scrubber is used to clean and cool recirculated exhaust gas, the scrubber is to satisfy the requirements of 7.1.9.

■ *Section 7* Pumping and piping

7.1 General

7.1.1 Pipe work and transfer systems which may carry chemical substances are to meet the requirements of Chapter 5 of the Rules for Ships for Liquid Chemicals. Lining steel pipe systems with corrosion-resistant materials is subject to special approval. The elasticity of the lining is not to be less than that of the supporting boundary material.

7.1.2 Pipe systems carrying sea-water or fresh water are to meet the requirements of Pt 7, Ch 1, Ch 2 and Ch 3. Where there is a risk of fresh-water or sea-water systems becoming contaminated with process chemicals, substances or effluent, pipe systems are to comply with 7.1.1.

7.1.3 Chemical transfer and control arrangements are to meet the requirements of Ch 5,5.6 of the Rules for Ships for Liquid Chemicals.

7.1.4 Bilge and effluent pumping and piping systems in the emissions abatement plant spaces are to be constructed of materials suitable for any chemicals or substances used by the emissions abatement plant, any effluent that is produced or any combination of substances on board which might result from accidental admixture.

7.1.5 Arrangements are to be provided for the control of the bilge and effluent pumping and piping system. They are to be installed in the emissions abatement plant spaces from within these spaces and also from a position outside the spaces.

7.1.6 Bilge and effluent pumping and piping systems for hazardous materials should, wherever possible, be installed in the space associated with the particular hazard.

7.1.7 Piping systems carrying chemical substances or effluents and by-products are to meet the requirements of Chapter 6 of the Rules for Ships for Liquid Chemicals. This requirement includes exhaust piping where such substances are injected into exhaust gas or where the exhaust gas passes through a liquid scrubber which uses chemical substances.

7.1.8 Where filters are used, they are to be capable of being removed for cleaning and replaced safely without interrupting emissions abatement plant or combustion machinery operations.

7.1.9 Where scrubbers are used, the following apply:

(a) Closed loop wet scrubbers are to have natural gravity fall drainage from the wet sump of the scrubber to the process tank or circulating pump suction, with the drain line dimensioned to accommodate 125 per cent of the maximum pumping capacity of the installed water pump(s). No valves are to be fitted to the drain line from the scrubber sump to the process tank unless it can be demonstrated that suitable precautions are in place to prevent the possibility of the scrubber filling with water and reverse-flowing into the combustion machinery exhaust duct. Where a valve is fitted to this line, the system is to be protected as for the overboard discharge valve of an open loop system, in accordance with Table 1.9.1.

(b) For open loop wet scrubbers, the overboard discharge valve and any other sea-water valves downstream of the scrubber are to be protected in accordance with Table 1.9.1. The sea suction valve(s) are also to have position indicators which are to give remote indication of valve position. The scrubber is to be mounted above the waterline under all normal ship operating conditions to prevent sea-water ingress into the scrubber.

(c) For wet scrubbing systems (open loop and closed loop), an overflow line is to be fitted to prevent the risk of reverse flow of water to combustion machinery. This overflow is to be dimensioned to accommodate 125 per cent of maximum capacity of installed water pumps and is to have no impairment to flow. This overflow line is to be directed to the process tank in closed loop or hybrid installations. On open loop installations, it is to be directed overboard. The overboard discharge is to have an effective means of preventing reverse flow of sea-water. Alternative arrangements to prevent the risk of reverse flow are subject to special consideration.

(d) Overboard discharge connections from scrubbers are to be positioned below the lowest operating waterline and are to be internally protected from effluent-induced corrosion.

7.1.10 Where applicable, tanks are to be maintained within the temperature limits of the chemicals and substances they contain so as to avoid risks of boiling, stress corrosion, freezing and other temperature-sensitive processes.

■ *Section 8*
Pressure vessels

8.1 General

8.1.1 Pressure vessels are to be in accordance with the requirements of the relevant Sections of Pt 8, Ch 1 or Ch 2 as applicable, or with agreed Codes and specifications normally used for similar plants in land installations, suitably modified and/or adapted for the Marine Environment.

8.1.2 Mounting arrangements are to take account of forces and moments generated at the supports. Mounting arrangements are to take account of thermal expansion and contraction.

8.1.3 Access is to be provided for inspection and checking of mountings, fittings, controls and pressure-relief devices.

8.1.4 Arrangements are to allow the pressure settings of pressure-relief devices to be checked.

8.1.5 Where provision is made to isolate pressure-relief devices from pressure vessels for maintenance purposes, at least two such pressure-relief devices are to be fitted. The isolating or blocking valves are to be arranged such that at least one pressure-relief device remains operational at all times.

■ *Section 9*
Electrical and control equipment

9.1 General

9.1.1 Electrical system(s) associated with emissions abatement plant are to meet the requirements of Pt 10, Ch 1.

9.1.2 Control system(s) associated with the emissions abatement plant are to meet the requirements of Pt 9, Ch 1.

9.1.3 Electrical and control equipment associated with the emissions abatement plant is to be compatible with any chemicals used and meet the requirements of Chapter 10 of the Rules for Ships for Liquid Chemicals.

9.1.4 Where flammable or toxic chemicals, gases or vapours are present, as identified in 3.3.1 and 3.3.2, or where there is a possibility that flammable gases and vapours can be produced as a result of deviations from normal operation, the defining of hazardous zones is to be in accordance with Pt 10, Ch 1,14.

As a minimum, for the detection of gas and vapours, a gas detection system is to be fitted which is to activate at a concentration corresponding to the substance safe occupational level. The locations of the detectors are to be determined relative to the layouts of the individual spaces and are to be indicated on the plan submission required by 3.3.9. Where it is not practicable to install a detection system, alternative proposals are to be submitted to ensure the safety of persons from exposure to such substances.

9.1.5 Process tanks which form part of the operating loop of any emissions abatement equipment are to have a high-level alarm, in accordance with Table 1.9.1. Effluent tanks which are not part of the normal process loop and which are used for storage of effluent or substances prior to discharge from the vessel are to be protected, in accordance with Table 1.9.1. Tank alarm and trip sensors are to be positioned at a point that will allow the system shut-down to operate before the tank overflows, based on the maximum design flow rates and shut-down response time. Where a low level is identified as presenting a risk to crew or machinery, tanks are to have a low-level alarm and a low-level trip. These are to be positioned so as to operate before a low level results in a hazardous condition, based on system design flow rates and a system shut-down response time.

Table 1.9.1 Machinery emissions to air abatement plant: alarms and safeguards

Item	Alarm	Note
Exhaust gas outlet temperature	High	
Exhaust gas inlet temperature	High	
Exhaust gas inlet temperature	Low	Only for selective catalytic reduction
Differential pressure across abatement plant unit	High	
Abatement plant by-pass valve in exhaust duct	Valve movement	*See* Note 1
Machinery exhaust duct isolating valve	Valve movement	*See* Note 2
Wet emissions abatement unit overboard discharge valve	Closed	Emissions abatement plant is to be shut down automatically, *see* Note 6
Wet emissions abatement unit overflow line flow detection	Flow present	Emissions abatement plant is to be shut down automatically, *see* Note 6
Wet emissions abatement water pressure	Low	
Wet emissions abatement unit water temperature	High	
Chemical feed flow	High	
Wet emissions abatement unit water level	1st Stage high	
Wet emissions abatement unit water level	2nd Stage high	Emissions abatement plant is to be shut down automatically, *see* Note 6
Chemical feed flow	High	Chemical feed pump is to be shut down automatically
Chemical feed flow	1st Stage low	
Chemical feed flow	2nd Stage low	Chemical feed pump is to be shut down automatically
Process tank level	1st Stage high	*See* Note 3
Process tank level	2nd Stage high	Emissions abatement plant is to be shut down automatically, *see* Note 3
Chemical storage tank level	1st Stage high	
Chemical storage tank level	2nd Stage high	
Chemical storage tank level	Low	
Chemical storage tank temperature	High	*See* Note 4
Chemical storage tank temperature	Low	*See* Note 4
Chemical tank containment bund level	High	Tank outlet quick-closing valve is to close automatically, *see* Note 5
Chemical tank containment drain line flow detection	Flow present	Tank outlet quick-closing valve is to close automatically, *see* Note 5
Exhaust gas recirculating fan failure	Failure	
Recirculating exhaust gas temperature return to engine	High	
Induced draught fan failure	Failure	Where fitted

NOTES
1. Only where a by-pass valve is fitted, *see* 3.3.5. This valve shall open to the by-pass position as part of the unit shut-down logic.
2. Only where fitted, *see* 5.1.
3. The process tank is any tank forming part of a wet abatement system flow loop or effluent tanks which receive bleed-off from the main flow loop, or such tanks not forming part of the system flow loop but which are essential for operation of the system, including those on exhaust gas recirculating installations, *see* 7.1.9. Where low level can present a hazard, process tanks are also to have low-level protection.
4. Where chemical substances are to be kept within a defined temperature range, alarms will be fitted, based on the allowable temperature range, *see* 5.1.2 and 7.1.10.
5. Chemical spillage detection alarm will depend on the means of spill containment fitted, *see* 5.1.2.
6. Wet emissions abatement unit shall include such systems fitted as part of the exhaust gas recirculating installations.

9.1.6 An Emergency Stop Function (E-Stop) is to be provided, which is to:

- Close quick-closing valves on chemical tank(s) (where applicable).
- Stop chemical feed pump(s) (where applicable).
- Where fitted, open exhaust gas cleaning by-pass valve.
- Stop scrubber water pumps and close scrubber water inlet valve (where applicable).

9.1.7 The E-Stop function is to be capable of being actuated from the machinery control room, the navigating bridge and from within compartments containing chemical tanks and exhaust gas cleaning plant.

9.1.8 Alarms and safeguards are to be provided for the critical system parameters in order to avoid danger to crew and machinery. As a minimum, the alarms and safeguards listed in Table 1.9.1 are to be fitted. Alarms and trip protection required by these Rules are to be independent of each other. Where the Risk Based Analysis required by 3.1.6 identifies that additional alarms and safeguards are required, these are to be implemented.

9.1.9 Where emissions abatement plant makes use of chemical substances, a means of monitoring abnormal flows of such chemicals is to be provided.

Volume 3, Part 1, Chapter 2
Integrated Propulsion Systems

Effective date 1 January 2014

■ *Section 3*
Control arrangements

3.1 Bridge control

3.1.4 ~~Means,~~ Emergency Stop Functions, independent of the bridge control system, are to be provided on the bridge to enable the watchkeeping officer to stop the main propulsion machinery in an emergency.

Volume 3, Part 1, Chapter 3
Propulsion and Steering Machinery Redundancy

Effective date 1 January 2014

■ *Section 1*
General requirements

1.2 Plans and information

1.2.3 ~~**Failure Mode and Effects Analysis (FMEA)**~~ **Risk Assessment (RA)**. For the propulsion systems, electrical power supplies, essential services, control systems and steering arrangements, ~~an FMEA~~ a RA report is to be submitted and is to address the requirements identified in Sections 2 and 5.

1.2.5 **Testing and trials procedures**. A schedule of testing and trials to demonstrate that the ship is capable of being operated with machinery functioning as described in Section 3 is to be submitted. In addition, any testing programme that may be necessary to prove the conclusions of the ~~FMEA~~ RA is to be submitted.

1.2.6 **Operating Manuals**. Operating Manuals are to be submitted for information and provided on board. The manuals are to include the following information:

(a) Particulars of machinery and control systems.
(b) General description of systems for propulsion and steering.
(c) Operating instructions for all machinery and control systems used for propulsion and steering.
(d) Procedures for dealing with the situations identified in the ~~FMEA~~ RA report.

Section 2
~~Failure Mode and Effects Analysis (FMEA)~~ Risk Assessment (RA)

2.1 General

2.1.1 ~~An FMEA~~ A Risk Assessment (RA) is to be carried out in accordance with Pt 1, Ch 2,17 and 2.1.2~~ to 2.1.7~~, for the propulsion systems, electrical power supply systems and steering systems to demonstrate that a single failure in active equipment or loss of an associated sub-system, *see* 1.1.4, will not cause loss of all propulsion and/or steering capability as required by a class notation. Typical sub-systems include associated control and monitoring arrangements, data communications, power supplies (electrical, hydraulic or pneumatic), fuel, lubricating, cooling, etc.

~~*2.1.2* The FMEA is to be carried out using the format presented in Table 3.2.1 or an equivalent format that addresses the same safety issues. Analyses in accordance with IEC 60812, *Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)*, or IMO MSC Resolution 36(63) Annex 4 – *Procedures for Failure Mode and Effects Analysis*, would be acceptable.~~

~~*2.1.3* The FMEA is to be organised in terms of equipment and function. The effects of item failures at a stated level and at higher levels are to be analysed to determine the effects on the system as a whole. Actions for mitigation are to be determined.~~

~~*2.1.4* The FMEA is to:~~
- ~~(a) identify the equipment or sub-system, mode of operation and the equipment;~~
- ~~(b) identify potential failure modes and their causes;~~
- ~~(c) evaluate the effects on the system of each failure mode;~~
- ~~(d) identify measures for reducing the risks associated with each failure mode; and~~
- ~~(e) identify trials and testing necessary to prove conclusions.~~

~~*2.1.5* At sub-system level it is acceptable, for the purpose of these Rules, to consider failure of equipment items and their functions, e.g., failure of a pump to produce flow or pressure head. It is not required that the failure of components within that pump be analysed. In addition, their failure need only be dealt with as a cause of failure of the pump.~~

~~*2.1.6* Where FMEA is used for consideration of systems that depend on software-based functions for control or co-ordination, the analysis is to investigate failure of the functions rather than a specific analysis of the software code itself.~~

~~*2.1.7*~~ *2.1.2* The ~~FMEA~~ RA is to establish that in the event of a single failure:
- (a) For **PSMR** and **PSMR★** notations, that not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems is available, and that steering capability is retained at a speed of seven knots.
- (b) For **PMR** and **PMR★** notations, that not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems remain available.
- (c) For **SMR** and **SMR★** notations, steering capability at a speed of seven knots is to be retained.
- (d) For **PSMRL★** notation, that the ship will retain the ability to use available installed prime mover capacity and installed propulsion systems that are unaffected by the failure and retain steering capability at a service speed of not less than seven knots.
- (e) For **PMRL★** notation, that the ship will retain the ability to use available installed prime mover capacity and installed propulsion systems that are unaffected by the failure.

~~**Table 3.2.1 Failure Mode and Effects Analysis**~~

System				Element							
Item No.	Component description	Function	Mode of operation	Failure mode	Failure cause	Failure detection	Effect of failure		Severity	Corrective action	Remarks
							On item	On system			

NOTE
The severity category is to be in accordance with the following:
(a) Catastrophic; (b) Hazardous; (c) Major or (d) Minor.

Section 5
Separate machinery spaces ★ (star) Enhancement

5.1 General

5.1.2 The machinery arrangements, control arrangements and ~~FMEA~~ Risk Assessment (RA) required by ~~Sections 2 to 4~~ Section 2, together with testing and trials requirements in Section 6, are to be complied with in addition to 5.2 to 5.8.

5.8 ~~FMEA~~ Risk Assessment (RA)

5.8.1 The ~~FMEA~~ RA required by 2.1.1 for the propulsion systems, electrical power supplies, essential services, control systems and steering arrangements is also to address the following:

(a) Fire in a machinery space or control room.
(b) Flooding of any watertight compartment which could affect propulsion or steering capability.
(c) Separation of machinery spaces.

Section 6
Testing and trials

6.1 Sea trials

6.1.3 Where the ~~FMEA~~ Risk Assessment report has identified the need to prove the conclusions, testing and trials are to be carried out as necessary to investigate the following:

(a) The effect of a specific component failure.
(b) The effectiveness of automatic/manual isolation systems.
(c) The behaviour of any interlocks that may inhibit operation of essential systems.

Volume 3, Part 1, Chapter 5
Replenishment at Sea (RAS) Systems

Effective date 1 January 2014

Section 6
Ship and arrangement requirements

6.4 Position of radar units and other sources of electromagnetic energy

6.4.1 RAS stations, observation positions and securing points are as far as practicable to be sited clear of sources of electromagnetic energy such as radars, communication transmitters, or lightning conductors. Where such equipment or the swept beam from radar aerials is in close proximity to any RAS facilities, a ~~risk assessment~~ Risk Assessment is to be undertaken, in accordance with Pt 1, Ch 2,17, to ensure that the dangers of RADHAZ are minimised.

Section 7
Ship operating system requirements

7.2 Machinery redundancy

7.2.2 Where ships are fitted with single screw propulsion and single rudder arrangements or having the additional **L** character assigned to a machinery redundancy notation, *see* ~~Pt 5, Ch 3~~ Pt 1, Ch 3, an evaluation of a detailed engineering and safety justification will be required, *see* 5.1.11. The evaluation process is to include the appraisal of ~~a Failure Modes and Effects Analysis (FMEA)~~ a Risk Assessment (RA), in accordance with Pt 1, Ch 2,17, to verify that sufficient levels of redundancy and monitoring are incorporated in the propulsion and steering systems to support effective manoeuvring control of the ship during RAS operations.

Volume 3, Part 3, Chapter 1
General Requirements

Effective date 1 January 2014

■ *Section 4*
Integration for EER notation

4.2 System integration

4.2.4 Where the integration involves control functions for essential services or safety functions, a robust system ~~analysis procedure, such as a Failure Modes and Effects Analysis,~~ Risk Assessment in accordance with Pt 1, Ch 2,17 is to be used to demonstrate that the integrated system will not render essential services inoperable as a result of single item failure.

Section numbering in brackets reflects any Section renumbering necessitated by any of the Notices that update the current version of the Rules for Naval Ships.

Volume 2, Part 4, Chapter 4

2.2.1(h)	6.6.5 *now reads* 6.6.6
	6.6.6 *now reads* 6.6.7
2.2.1(n)	6.6.6 *now reads* 6.6.7

Volume 2, Part 6, Chapter 1

Table 1.8.1	7.1.2 *now reads* 7.1.3
	7.1.3 *now reads* 7.1.4

Volume 2, Part 10, Chapter 1

1.4.3	11.1.3 *now reads* 11.1.4
11.8.21 (*11.8.22*)	11.5.7 *now reads* 11.5.8
16.1.3	9.1.9 *now reads* 9.1.10
Table 1.16.1	9.1.12 *now reads* 9.1.13
	9.1.13 *now reads* 9.1.14

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